EXPERIMENTS IN THE WESTERN ATLANTIC NORTHEAST DISTANT WATERS TO EVALUATE SEA TURTLE MITIGATION MEASURES IN THE PELAGIC LONGLINE FISHERY

REPORT ON EXPERIMENTS CONDUCTED IN 2001
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Executive Summary

This report presents the results of research conducted in 2001 in the Western Atlantic Ocean by the National Marine Fisheries Service in cooperation with the U.S. domestic pelagic longline commercial fishery. The purpose of the research is to develop mitigation measures capable of reducing the incidental take and mortality of sea turtles by pelagic longline gear. A multiyear project was initiated by the NMFS Southeast Fisheries Science Center in 2001 as a component of an overall effort by the Southeast Fisheries Science Center, the Southwest Fisheries Science Center, the Northeast Fisheries Science Center, the Southeast and Northeast Regional Offices, the NMFS Highly Migratory Species Division, the NMFS Protected Species Division, the NMFS Sustainable Fisheries Division, the domestic pelagic longline industry, and the University of Florida to address sea turtle mortality in the pelagic longline fishery.

Eight domestic commercial pelagic longline vessels were contracted by NOAA Fisheries to provide platforms for evaluation of potential mitigation techniques and to collect data on variables effecting sea turtle interaction with longline gear. The techniques evaluated were selected from research priorities recommended by an ad hoc advisory group. Treatments selected for evaluation based on the best scientific information available were 1) use of blue dyed squid and 2) positioning of hooks away from floats. In addition to evaluating the effect of the treatments, data were collected on 18 other variables and the effect of these variables on turtle interaction rates.

The eight commercial vessels made 186 sets over two trips to the Northeast Distant waters (NED) between September 4, 2001 and October 29, 2001. A total of 164, 429 hooks were fished and 142 loggerheads and 77 leatherback turtles were caught with 0 observed mortalities. Analysis of loggerhead turtle catch rates for blue dyed squid off float (treatment sections) and control sections (natural color squid) indicated an increase of 4% in the treatment sections which was not found to be statistically significant. For the natural squid off float treatment there was a 16.3% decrease in loggerhead turtle catch in the treatment sections which was also not found to be statistically significant. There were 3 sets that were considered as outlier sets for loggerhead turtle catch when compared to historical observer data. Analysis of the data with outlier sets excluded did not change the results. Analysis of leatherback turtle catch rates for blue dyed squid off float (treatment sections) and control sections (natural color squid) indicated a 31.3% increase in the treatment sections which was not found to be statistically significant. For the natural squid off float treatment there was an increase of 60% in the treatment sections which was also not found to be statistically significant. A sequential analysis indicated that there was enough evidence to terminate the sampling and conclude that there was no significant reductions in turtle catch rates due to the two treatments tested either separately or combined.

Of the other variables investigated, haul order, soak time, and hook position were the only variables found to have a significant effect on loggerhead catch rates. For loggerhead turtles there was a 200% increase in loggerhead takes between the first half and the second half of set hauls. This increase was found to be statistically significant. Significant possible explanatory variables included an increase of 143% in daylight hook soak time and a 20% increase in night hook soak time. When the data was partitioned by quarter sets there was an increase of 385% in loggerhead interaction between the first quarter of hauls and the last quarter of hauls which was found to be statistically significant. Analysis of data from the control sections on effect of hook position showed that there was weak evidence to indicate a higher loggerhead turtle catch rate for hooks fished under a float versus hooks fished between floats. We found no evidence, however, to indicate that fishing hooks away from the floats can reduce the catch rates of loggerhead turtles. There was strong evidence to indicate a higher catch rate for leatherback turtles for hooks fished under floats. Leatherback turtle catch data in both the treatment and control sections indicated a disproportionate distribution with a higher catch rate in the hook positions nearest to the float. The two hook positions 20 fathoms from the float (treatment) had individual catch rates similar to the single hook position under the float (control). This information indicates there may be a zone of influence that extends beyond 20 fathoms from the float. Based on this information, the fishing configuration with the hook directly under the float appears to be more favorable than fishing hooks 20 fathoms from the float.

A generalized linear modeling approach was used to evaluate turtle catch rates adjusting for pairing of treatment and control sections within a set, set order, haul order, daylight soak time, and night soak time. In the fitted model, average daylight soak time was the only significant explanatory variable for loggerhead catch. The model indicates that a significant reduction in loggerhead catch on pelagic longline gear may be achieved by reducing daylight soak time.

Several prototype line cutters and de-hookers were evaluated to determine their efficiency in removing longline gear from turtles. The NOAA "Laforce" line cutter was found to be the most effective line cutter. The ARC de-hooker was found to be the most effective in removing external hooks from turtles in the water. The flip stick and Scottie's de-hookers were efficient in removing mouth hooks and external hooks on deck. These and other designs will be further evaluated and a protocol developed for efficient safe removal of longline gear from sea turtles.

A pilot post hooking study was conducted in conjunction with the sea turtle mitigation experiments to determine the effectiveness of pop up archival transmitting tags for estimating sea turtle post hooking survival rates. Seven control loggerhead turtles and 9 loggerhead turtles with ingested hooks were tagged in the NED. At the time of this report 4 control turtle tags and 2 treatment tags (deeply hooked turtles) had released and transmitted data.

Introduction

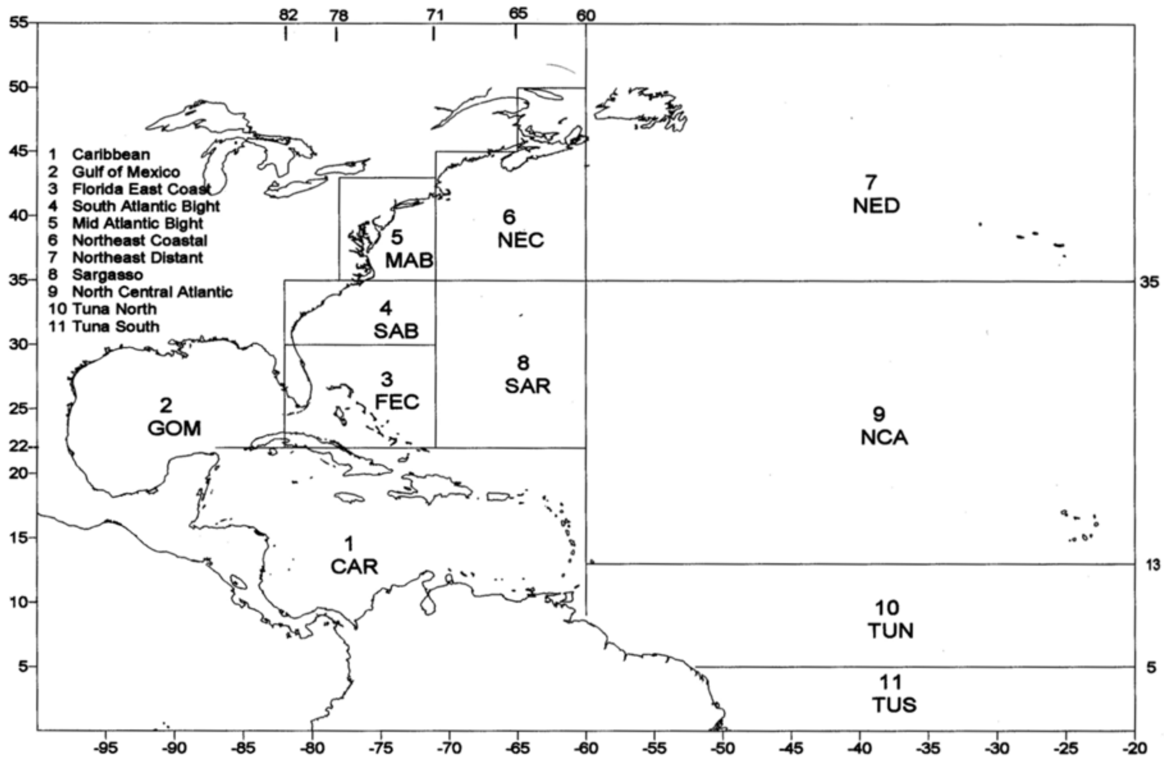
In August, 2000 the National Marine Fisheries Service's Southeast Fisheries Science Center was directed by NMFS Headquarters to develop and implement a three year cooperative project with the pelagic longline industry. The objective of the project was to develop mitigation measures to reduce the incidental capture and mortality of threatened and endangered sea turtle species associated with pelagic longline fishing gear. An ad hoc advisory group from the U.S. pelagic longline fishing industry, the Southeast Fisheries Science Center, the Southwest Fisheries Science Center, the Northeast Regional Office, Southeast Regional Office, NMFS Highly Migratory Species Division, NMFS Protected Species Division, and the University of Florida met in Miami, Florida in April 2001. The purpose of the meeting was to review a draft proposal, to plan and prioritize experiments in the Western Atlantic Ocean Northeast Distant Area (NED) and to coordinate efforts in the Western Atlantic with efforts in the Pacific and Azores (Appendix I). A research proposal was submitted to NMFS in July 2001 (Appendix II) and research initiated in September 2001.

Data collected during 2001 was analyzed by the SEFSC and the results presented at a meeting of the ad hoc advisory group in Miami, Florida in March 2002. The advisory group reviewed the results of the data analysis and made recommendations for 2002 research priorities. This report presents the results of the 2001 pelagic longline mitigation experiments.

Methodology

The National Marine Fisheries Service conducted scientific research in the Western North Atlantic under authorization of ESA section 10 permit #1324 to develop new technologies and fishing practices to reduce the incidental take and mortality of endangered and threatened sea turtle species by pelagic longline gear. Eight domestic fishing vessels were contracted by NMFS to provide platforms for research in the Northeast Distant (NED) statistical sampling area (Figure 1) between September and November, 2001. Participating U.S. pelagic longline vessels carried NMFS observers and fished their gear in a specified, pre-determined manner designed to test one or more variables affecting sea turtle bycatch.

Figure 1. Pelagic Longline Fishing Areas Source*: Cramer and Adams, 2000.*



Based on the recommendations of the pelagic longline gear ad hoc advisory group the priorities for 2001 experiments in the NED were:

1. Evaluation of blue dyed squid bait
2. Evaluation of mackerel bait
3. Moving hooks away from floats
4. Stiff buoy lines and gangions
5. Offset circle hooks

The anticipated potential effectiveness of individual mitigation measures to reduce sea turtle interactions based on available data and information was expected to be between 25% and 50%. It was hoped that combinations of potential mitigation measures would exceed 50%. The experiments simultaneously evaluated two experimental gear configurations against a control treatment.

A power analysis was conducted to estimate the experimental fishing effort required to detect a fishing method that has different degrees of effectiveness in reducing bycatch of turtles in comparison with the control fishing method. The null hypothesis for the experiment was constructed so that the burden of proof is on the treatment to be proven; that is, we initially assume that the treatment is not effective and must "prove" statistically that it is effective. The factors affecting the required level of effort are the actual sea turtle catch rates and variability, the effectiveness of a measure being tested (*i.e.*, the difference in catch rate between the experimental and control treatments), and the statistical risk of error. We projected the expected sea turtle catch rates based on the average catch rate observed in the Grand Banks fishery over 1991-1999 and using only the higher catch rate in the most recent available year's data (1999). For the expected effectiveness of measures, we looked at 50% and 25% bycatch reduction. We believe that this research should attempt to "prove" or disprove measures that may have bycatch reductions as low as 25%. We believe that 25% is the minimum acceptable reduction rate that may be useful to sea turtle management and conservation. Reduction rates below 25% would also require an exponential increase in effort to detect. We have set the alpha and beta levels at 10% and 20%, respectively, which are typical levels of statistical risk for this type of gear evaluation experiment. Table 1 shows the results of the power analysis considering these factors, including the required number of hooks for two treatments and corresponding controls.

Table 1. Estimated sample sizes required to conduct proposed bycatch reduction experiment in the Grand Banks longline fishery. Estimates are the result of power analysis that considered the observed CPUE of each species in the Grand Banks as a 9-year average and also the single-year value for 1999. The power analysis was performed to detect bycatch reduction rates, relative to the control, of 25% and 50% with alpha set at 10% and beta set at 20%.

Species	Assumed Sea Turtle Capture Rates	Assumed Bycatch Reduction	# of Hooks Required For Each Treatment	# of Hooks Required for 2 Treatments and corresponding Controls
Loggerhead	91-99 Average	25%	152,708	**610,832**
Loggerhead	1999 Value	25%	89,585	358,340
Loggerhead	91-99 Average	50%	31,972	127,888
Loggerhead	1999 Value	50%	18,747	74,988
Leatherback	91-99 Average	25%	325,208	1,300,832
Leatherback	1999 Value	25%	125,463	501,852
Leatherback	91-99 Average	50%	68,047	272,188
Leatherback	1999 Value	50%	26,254	105,016

Table 1 illustrates the strong effect that the different catch rates and bycatch reduction effectiveness can have on the required level of effort. For planning purposes, we are focusing on testing measures that would have a 25% effectiveness for loggerhead turtles. The associated level of fishing effort (up to 611,000 hooks) was planned to be completed in about 51 fishing trips to the NED over 1-1/2 years. We assumed that average trips are 15 overnight sets of 800 hooks.

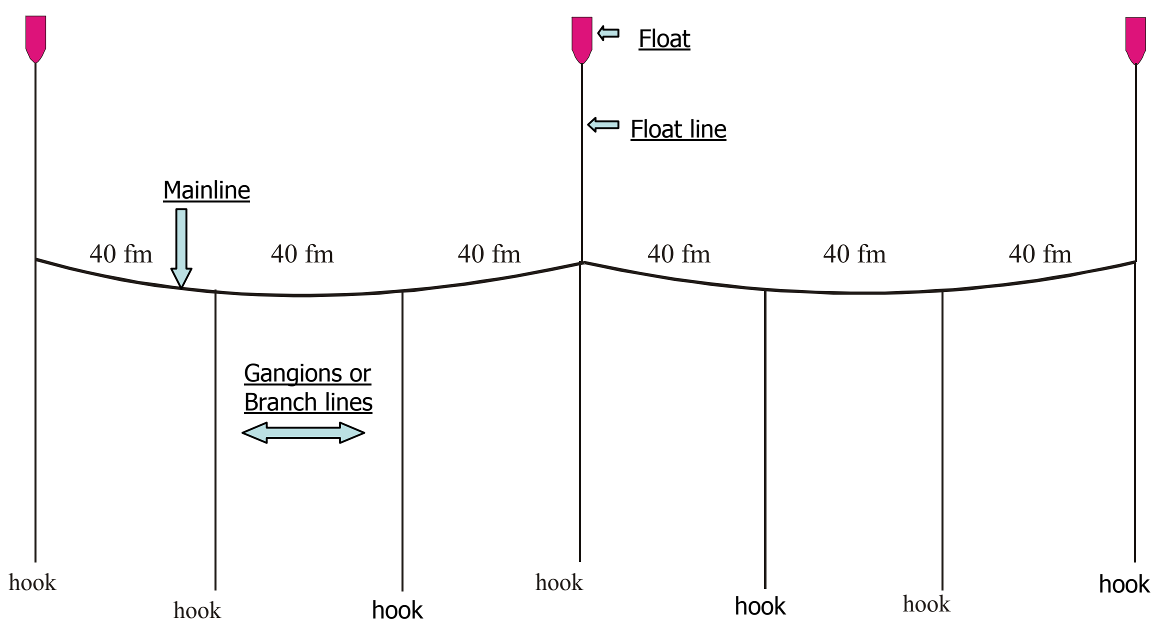
Because of the lower catch rates of leatherbacks, the required level of effort to test these measures on leatherbacks at the 25% effectiveness level was not feasible. Of course, if any of the measures prove more effective for leatherbacks than a 25% reduction, then we may be able to detect that difference with these levels of effort.

The 1st and 3rd priority recommendations from the ad hoc advisory group were chosen for evaluation during the first year of the project due to operational problems in testing mackerel in combination with other recommended treatments. The treatment sets chosen were:

1) natural squid bait with no hooks under the float lines
2) blue-dyed squid bait with no hooks under the float lines.

On all of the treatment sets the hooks adjacent to float lines were spaced 20 fathoms from the float lines and hooks not adjacent to float lines were spaced 40 fathoms apart. The control sets used natural squid bait with hooks deployed at 40-fathom intervals and with hooks directly under each float line. Figure 2 illustrates the typical longline gear configuration and terminology.

Figure 2. Typical longline configuration and terminology



The vessels deployed one half of each set as a control and one half as treatment. The half of the set (first half or second half) which was the control was assigned in a predetermined random order. Other than the specified bait and gear configuration, the vessel captains determined when and where sets are made according to their normal practice. Vessels set a minimum of 822 hooks per set with equal numbers of hooks for control and treatment sections. Gangions were 3-10 fathoms long with a 45 gram swivel weight attached 1.5-3.0 fathoms from the hook. All hooks were swordfish style 25°-30° offset "J" hooks. Light stick color and placement was consistent within a set. Natural squid was used on all control portions of sets. Gear sections included 10 bullet floats then a poly ball, 10 bullet floats then a poly ball, 10 bullet floats then a poly ball, 10 bullet floats then a radio beacon or high flyer. Vessels set 3 hooks between floats and float lines were 1-7 fathoms long. Gangions were at least 10% longer that the float line length. All sets were made no earlier than one hour before sunset and soak time was a minimum of 6 hours except for a few exceptions due to sea condition and operational problems. For control portions of sets the gangions were spaced 40 fathoms apart and a gangion was placed immediately adjacent to the every float line attachment point. For treatment portions of sets, the gangion adjacent to each float line attachment point was placed at least 20 fathoms from the attachment point. Gangions not adjacent to float line attachment points were 40 fathoms apart. Vessel operators were provided a metronome for measuring spacing of gangions and drop lines on the mainline.

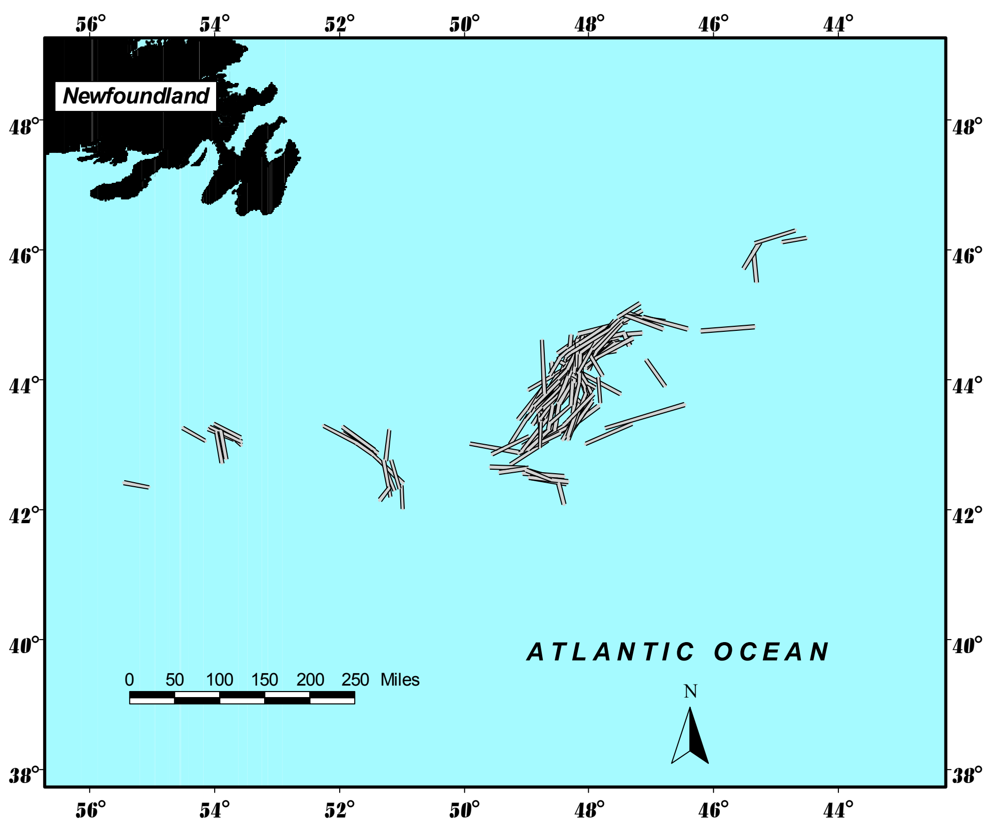
Observers collected a suite of data on forms generated by the SEFSC Pelagic Longline Observer Program including the Longline Gear Configuration Log, the Longline Haul Log, and the Individual Animal Log, the incidental capture log and the Sea Turtle Life History Form. Observers recorded the number of all species hooked on each bait type and the position of the hook relative to floats. Participating captains, crews, and observers followed NOAA guidelines and permit requirements for handling marine turtles hooked or entangled on longline gear. Turtles hooked or entangled were brought on board using dip nets if size permitted and attempted to remove all gear following recommended procedures. For turtles that could not be brought aboard, gear removal was attempted using line cutter and de-hooker prototypes being developed as part of the turtle mitigation research project. Prototype line cutters and de-hookers were evaluated by crews and observers and information on performance provided to NMFS. All turtles brought aboard were measured and tagged with standard flipper tags and PIT tags and released. Turtles that appeared stressed were maintained onboard and given the opportunity to revive before release. Sixteen loggerhead turtles were outfitted with archival pop-up satellite tags (PAT) for the purpose of evaluating their effectiveness for the study of turtle life history, and to investigate the effectiveness of the technique for collecting information on post hooking survival.

The estimates of catch rates per hook of control and treatment groups were computed from the sample data. Using these estimates, a one-tailed hypothesis test was conducted to test if the true catch rate for the treatment group is lower than that of the control group. The Fisher's exact test and the likelihood ratio test was performed as well and examined. A confidence interval on the difference in the true proportions was computed. A test on one dimensional data "multinomial proportion" was used to compare the catch rates among various quartiles of set hauls and also among the hook positions. A sequential analysis design (Armitage, 1975; Kim and Demets, 1987; Chang et.al, 1988) was used to test for possible early termination of the experiment (with enough evidence) while controlling for type I and type II error. A generalized linear model (logistic regression approach) was used to investigate the relationship between a categorical outcome (catch or no catch) and a set of explanatory variables (control or treatment, soak time, haul order, etc). The model allowed comparison of catch rates between treatment and control adjusting for other variables.

Results

Eight commercial vessels made 186 sets over two trips each to the Northeast Distant Waters (NED) between September 4, 2001 and October 29, 2001 (figure 3). A total of 164,429 hooks were set; 41, 264 hooks were set with blue dyed bait treatment paired with 41,412 control hooks, 41,024 hooks were set with natural bait treatment paired with 40,728 control hooks. There were 142 takes of loggerhead turtles and 77 takes of leatherback turtles with 0 observed mortalities. One loggerhead and one leatherback not included in the analysis were caught on a section of gear that broke away from the mainline and was not hauled until the following day. Therefore, 141 loggerhead turtles and 76 leatherback turtles were included in the analysis. All conditions of the ESA Section 10 permit were followed and a detailed list of species and total number of ESA-listed animals taken, the manner of take, and the dates and locations of take are given in Appendix III.

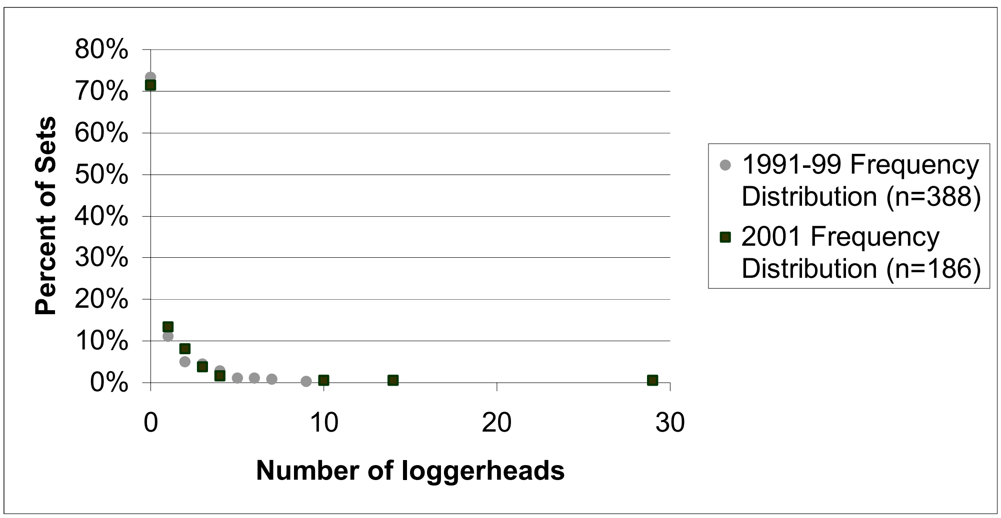
Figure 3. Location of 186 longline sets made by commercial pelagic longline vessels participating in the 2001 sea turtle mitigation experiments.



The effect of treatments on turtle CPUE

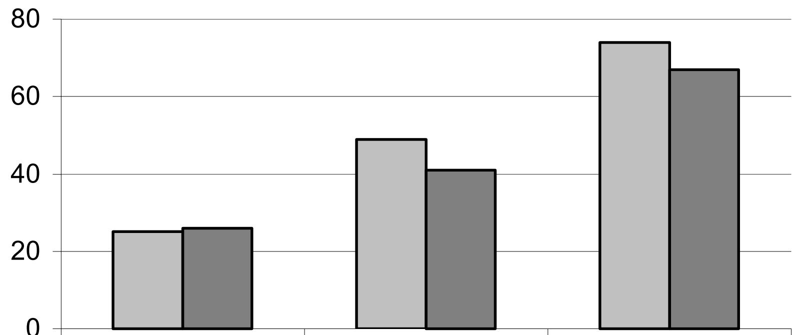
The frequency distribution of loggerhead turtle interactions with longline sets from the 2001 NED experiments is compared in Figure 4 to the historical distribution from 1991-1999 historical observer data. Seventy two percent of the 2001 sets had no loggerhead turtle takes compared to 73% from the historical data. Thirteen percent of the sets had 1 turtle take compared to 11% from the historical data. The percentage of sets that had 2 or more turtles ranged from less than 1% to 8%. Three of the 2001 sets had 10 or more turtles in a single set. Twenty nine turtles were taken on a single set. Analysis of the distribution of takes indicated that these sets had contradictory characteristics compared to the rest of the data and for purposes of the data analysis for effect of treatments and variables effecting turtle CPUE were treated as outliers. Effect of treatment data are presented both with and without the outlier data.

Figure 4. Loggerhead turtle take frequency distribution for 2001 experimental data and 1991-99 historical observer data.



The number of loggerhead turtles caught for the treatment and control sections of the gear for all sets are presented in Figure 5. In the blue dyed bait (all gangions off of the float) experiment, the catches of loggerhead turtles for the control and treatment sections were 25 and 26 respectively, which was an increase of 4% in the treatment section. This increase was not found to be statistically significant (p-value = 0.890). The catches of loggerhead turtles for the control and treatment sections in the natural bait (all gangions off of the float) experiment were 49 and 41 respectively, which was a decrease of 16.3% in the treatment section. This decrease was also not found to be statistically significant (p-value = 0.400). Combining the data from the two treatments results in a total decrease of 9.5% for the treatment section over the control (p-value = 0.557).

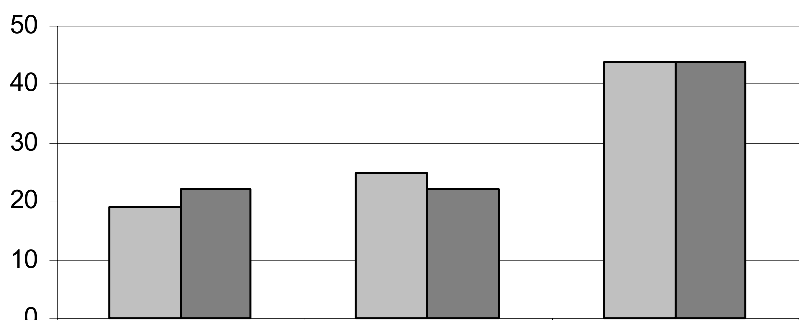
Figure 5. Effect of treatments on loggerhead turtle CPUE for all sets.



	Blue Dye	Natural	Total
Control	25	49	74
Treatment	26	41	67

The number of loggerhead turtles caught for the treatment and control sections of the gear for sets excluding outliers are presented in Figure 6. In the blue dyed bait (all gangions off of the float) experiment, the catches of loggerhead turtles for the control and treatment sections were 19 and 22 respectively, which was in increase of 16 % in the treatment section. This increase was not found to be statistically significant (p-value = 0.643). The catches of loggerhead turtles for the control and treatment sections in the natural bait (all gangions off of the float) experiment were 25 and 22 respectively, which was a decrease of 12% in the treatment section. This decrease was also not found to be statistically significant (p-value = 0.664). Combining the data from the two treatments results in an equal catch rate (44) for control and treatment sections of the gear.

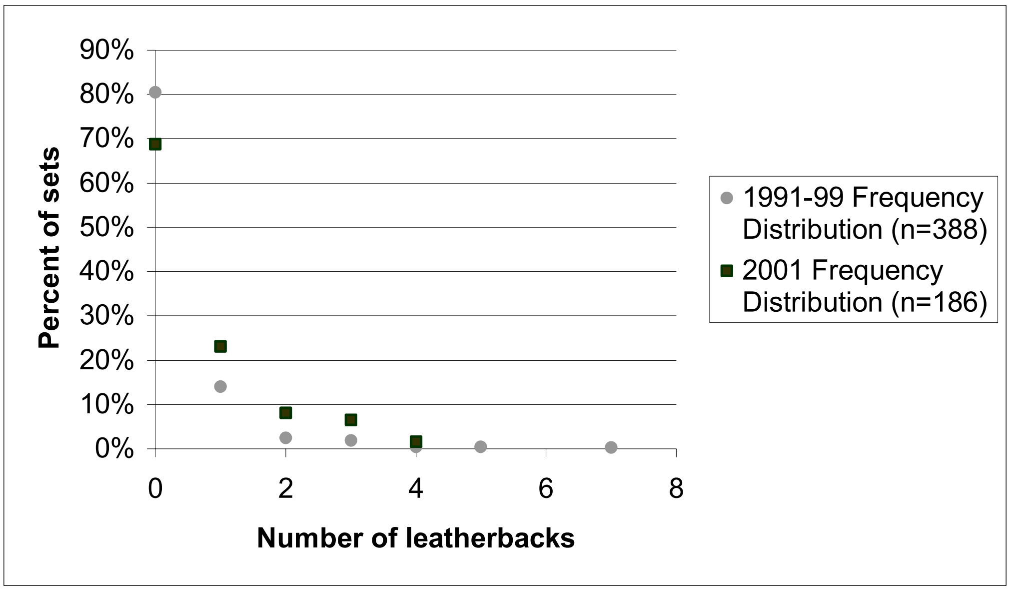
Figure 6. Effect of treatments on loggerhead turtle CPUE for all sets excluding outliers.



	Blue Dye	Natural	Total
Control	19	25	44
Treatment	22	22	44

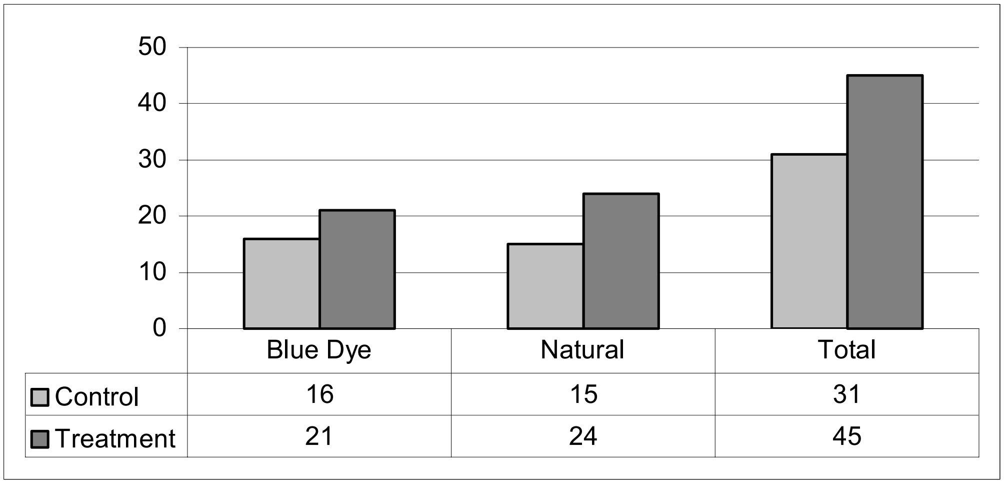
The frequency distribution of leatherback turtle interactions with longline sets from the 2001 NED experiments is compared in Figure 7 to the historical distribution from 1991-1999 historical observer data. Sixty nine percent of the 2001 sets had no leatherback turtle takes compared to 80% from the historical data. Twenty three percent of the sets had 1 turtle take compared to 14% from the historical data. The percentage of sets that had 2 or more turtles ranged from less than 2% to 8%. Less than 1.6% of all sets had more than 3 leatherback turtles and the greatest number for a single set was 7 from the historical observer data.

Figure 7. Leatherback turtle take frequency distribution for 2001 experimental data and 1991-99 historical observer data.



The number of leatherback turtles caught for the treatment and control sections of the gear are presented in Figure 8. In the blue dyed bait (off of the float) experiment, the catches of leatherback turtles for the control and treatment sections were 16 and 21, respectively, which was in increase of 31.3 % in the treatment section. This increase was not found to be statistically significant (p-value = 0.417). The catches of leatherback turtles for the control and treatment sections in the natural bait (off of the float) experiment were 15 and 24 which was in increase of 60% in the treatment section. This increase was also not found to be statistically significant (p-value = 0.200). Combining the data from the two treatments results in a total increase of 45% for the treatment section over the control (p-value = 0.135).

Figure 8. Effect of treatments on leatherback turtle CPUE for all sets.



Effect of other variables on turtle CPUE

Other variables investigated for effect on sea turtle CPUE included: fishing location, photoperiods, set/haul order, water temperature, vessels, and gear parameters including gangion test strength, leader length, mainline color, gangion color, mainline diameter, gangion diameter, hook depth, hook position, hooking location, and hook size. Of the variables investigated, haul order, soak time, and hook position were the only variables found to have a significant effect on loggerhead CPUE, but the 3 outlier sets were found to be contradictory to the rest of the data.

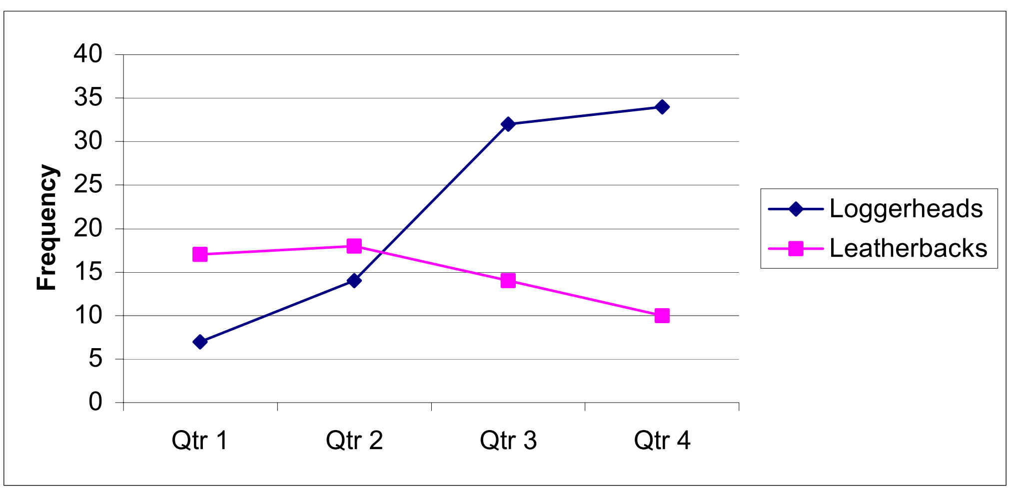
The effect of haul order on turtle CPUE, and the average daylight and night hook soak times are presented in Table 2. The sunrise and sunset times used for calculating daylight and night soak time are based on tables for a centralized area located at 45 degrees north latitude and 50 degrees west longitude. The average daylight soak time per hook in a given set was estimated by taking the average of maximum and minimum daylight soak time per hook in the set. For loggerhead turtles there was a 200% increase in takes between the first half and the second half of set hauls. This increase was found to be statistically significant (p-value = 0.000). For leatherback turtles there was an 8% decrease between the first half and the second half of set hauls which was not found to be statistically significant (p-value = 0.815). For the second half of the set hauls there was a 143% increase in average minutes of daylight soak time per hook which was found to be statistically significant (p-value = 0.000). There was also a 20% increase in average minutes of night soak time per hook for the second half of set hauls which was also found to be statistically significant (p-value = 0.000).

Table 2. Effect of haul order on turtle CPUE (excluding 3 outlier sets).

	FIRST HALF OF HAUL	SECOND HALF OF HAUL	% CHANGE	P-VALUE
Loggerheads	22	66	200 %	~0.000
Leatherbacks	38	35	-8 %	0.815
Number of hooks	80908	80827	-0.1 %	
Average minutes of daylight soak time per hook	177.4	430.3	143 %	~0.000
Average minutes of night soak time per hook	483.3	581.2	20 %	~0.000

Loggerhead and leatherback turtle catches were examined by quarter set to further investigate the relationship between haul order and turtle CPUE. The frequency of turtle catches by quarter set is presented in figure 9. There was a 385% increase in loggerhead turtle interaction between the first quarter of hauls and the last quarter which was found to be statistically significant (p-value < 0.0001). There was a decrease in leatherback interaction between the first quarter of hauls and the last quarter which was found not to be statistically significant (p-value = 0.4528).

Figure 9. Effect of haul order on loggerhead and leatherback turtle CPUE by quarter set.

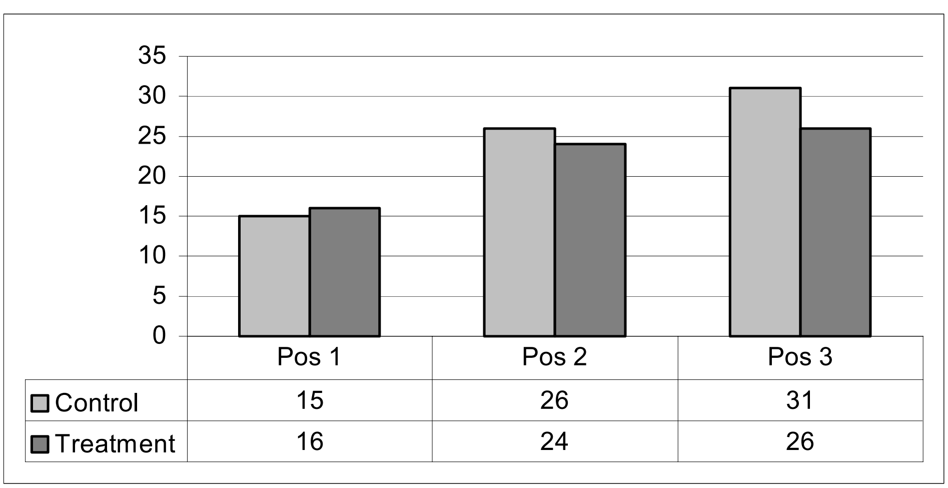


The distribution of loggerhead turtles by hook position is shown in Figure 10. Of the 141 loggerheads included in the analysis, 138 had recorded hook positions. In the control section of the gear, the loggerhead catches were 15, 26, and 31 in the hook positions 1, 2, and 3, respectively. Hooks positions 1 and 2 were located at equal distances of 40 fathoms from a float while hook position 3 was located directly under a float. A statistical analysis was conducted to determine if position 3 had a significantly higher catch rate than its fair (uniform) share of 33.33%. The p-value for the test was 0.0401 (0.0801 for two-sided test) implying a significantly higher catch rate than one-third in the hook position 3. However, the magnitude of the p-value does not provide very strong evidence for it.

In the experimental section of the gear, the loggerhead catches were 16, 24, and 26 in the hook positions 1, 2, and 3, respectively. Hook positions 1 and 3 were 20 fathoms away on each side of a float and hook position 2 was located 60 fathoms from a float. A statistical analysis was conducted to determine if position 2 had a significantly lower catch rate than its fair (uniform) share of 33.33%. The p-value for the test was 0.3008 (0.6015 for two-sided test) giving no evidence to conclude a lower catch rate than one-third in the hook position 2.

In the control sections of the experiment, we found weak statistical evidence indicating a higher catch rate of loggerhead turtles in hook position 3 (located under the float)(p-value = 0.0401). In the experimental sections of the gear, hooks were placed on the mainline 20 fathoms on either side of a float to determine if interactions associated with the floats would be reduced. However, we found no significant difference in the catch rates of loggerhead turtles between the control and the experimental sections of the gear (p-value = 0.557). Therefore, we have no evidence to favor the hook arrangement in the experimental sections over the control sections for reducing the catch rates of loggerhead turtles.

Figure 10. Loggerhead turtle distribution by hook position.

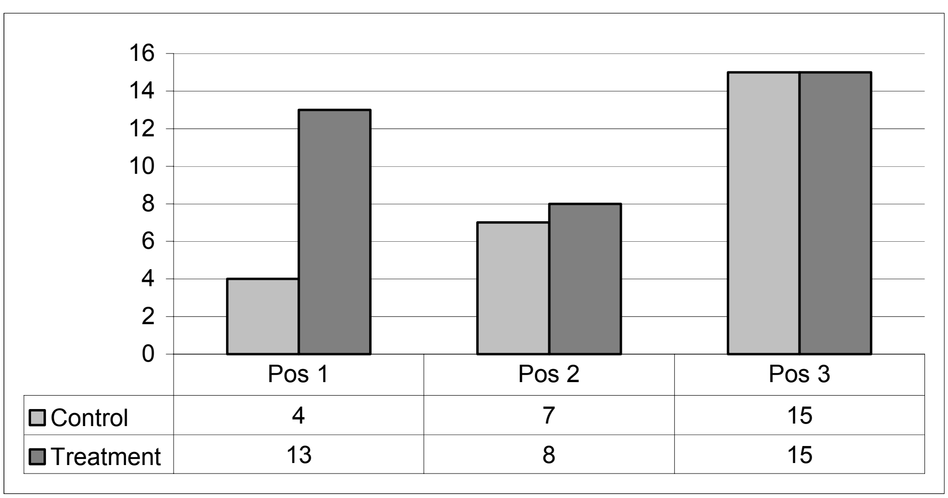


The distribution of leatherbacks by hook position is shown in Figure 11. Of the 76 leatherbacks included in the analysis, 62 had recorded hook positions. In the control section of the gear, the leatherback catches were 4, 7, and 15 in the hook positions 1, 2, and 3, respectively. Hooks positions 1 and 2 were located at equal distances of 40 fathoms from a float while hook position 3 was located directly under a float. A statistical analysis was conducted to determine if position 3 had a significantly higher catch rate than its fair (uniform) share of 33.33%. The p-value for the test was 0.0042 (0.0084 for two-sided test) implying a significantly higher catch rate than one-third in the hook position 3.

In the experimental section of the gear, the leatherback catches were 13, 8, and 15 in the hook positions 1, 2, and 3, respectively. Hook positions 1 and 3 were 20 fathoms away on each side of a float and hook position 2 was located 60 fathoms from a float. A statistical analysis was conducted to determine if position 2 had a significantly lower catch rate than its fair (uniform) share of 33.33%. The p-value for the test was 0.0787 (0.1573 for two-sided test) giving a borderline (marginal or weak) evidence to conclude a lower catch rate than one-third in the hook position 2.

Although not statistically significant, both treatments resulted in an increased interaction with leatherback turtles. In both the treatment and control sections, the data indicate a disproportionate distribution with a higher catch rate in the hook positions nearest to the float. The two hook positions (1 and 3) 20 fathoms from a float in the treatment sections had individual catch rates similar to the single hook (position 3) in the control section. This information indicates there may be a zone of influence that extends beyond 20 fathoms from the float. The doubling of effort in this area in the treatment sections may have influenced the overall higher catch rate in the treatments (31 in the control versus 45 in the treatment). Based on this information, the hook configuration in the control section of this experiment appears to be the more favorable of the two for minimizing interactions with leatherback turtles.

Figure 11. Leatherback turtle distribution by hook position.



A generalized linear modeling approach was used to evaluate turtle catch rates adjusting for pairing of treatment and control sections within a set, set order, haul order, daylight soak time, night soak time, etc. A logistic regression approach was used to investigate the relationship between a categorical outcome (catch or no catch) and a set of explanatory variables. The model parameters were estimated using direct maximum likelihood method or interactive algorithms. In the fitted model, average daylight soak time was the only significant explanatory variable (p-value < 0.05) for loggerhead catch. The exact same model and inferences were derived from fitting a poisson regression model. Even though significant, the model did not fit the data well. The model implied that for an extra 100 minutes of average daylight soak time, the odds of loggerhead catch increases by a factor of 1.35. These preliminary results indicate a significant reduction in loggerhead catch on pelagic longline gear may be achieved by reducing daylight soak time but warrant further experimentation and investigation. None of the explanatory variables were found to be significant for leatherback interactions.

Evaluation of prototype line cutters and de-hookers

Several prototype line cutters and de-hookers were evaluated by observers and vessel crews for efficiency in safely removing longline gear from sea turtles. Prototype line cutters evaluated in 2001 are shown in Figure 12. Not all vessels tested all prototypes and some vessels were more successful at removing gear from turtles than other vessels. The results of the first year of evaluation indicated that the most efficient design for removing line from hooked or entangled turtles was the NOAA “LaForce” line cutter. There were some operational problems reported for the line cutter, including cutter blades chipping and corroding, handle not long enough to reach turtles in the water and malfunction of extending handle. Modifications to the line cutter have been made and the new design will be extensively evaluated in 2002.

Figure 12. Prototype line cutter designs.

De-hooker designs evaluated in 2001 are shown in Figure 13. The flip stick and Scotty's model worked the best on mouth hooked loggerhead turtles. The ARC model worked best on foul hooked leatherback turtles but some operational problems were encountered. Problems included pole length too short to reach turtles on some vessels, the size tested did not work well on sharks, with 10/0 size hooks, or mouth hooked loggerhead turtles. The ARC has been redesigned based on the information provided by the observers and captains and all of the designs will be further tested in 2002 in order to develop a protocol for efficient safe removal of longline gear from sea turtles.

Figure 13. Prototype de-hooker designs.

Flip Stick

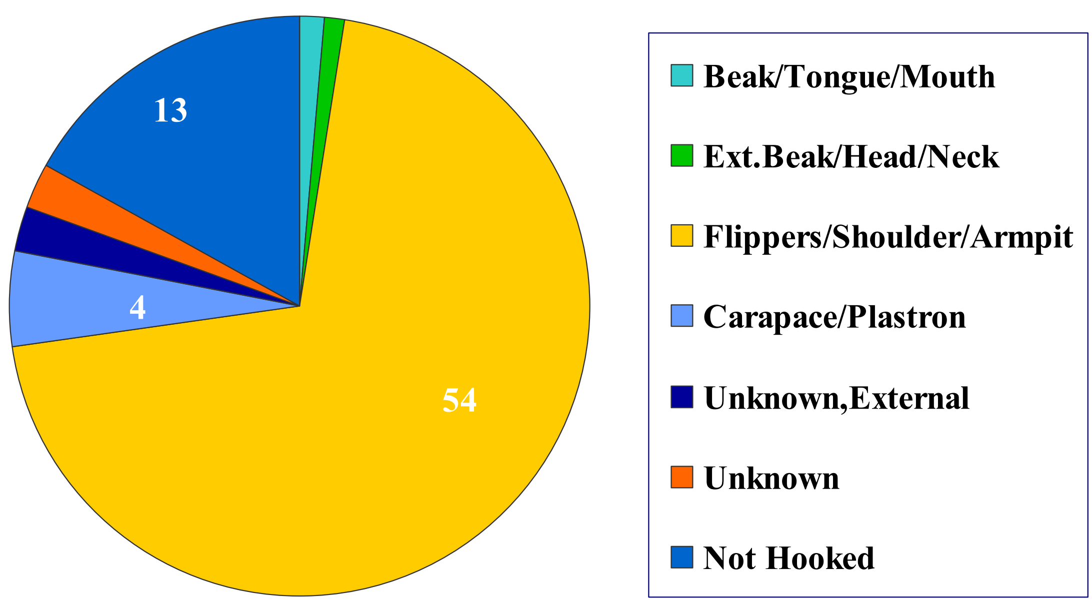
ARC

Scottie's

Turtle Demographics

The locations of hooks observed in leatherback turtles are shown in Figure 14. Of the 77 leatherback turtles caught during the experiments most were foul hooked in the flipper, or armpit. Twenty seven of the leatherback turtles caught also were entangled in the gangions or float lines. Fifty percent of the external hooks were removed from leatherbacks and all line was removed from 35 turtles. It is anticipated that with equipment modifications and improved protocols the percentage of external hooks and line that can be removed safely and efficiently will be greatly increased in 2002 experiments.

Figure 14. Hook locations in leatherback turtles.



The locations of hooks observed in loggerhead turtles are shown in Figure 15. Of the 142 loggerheads caught during the experiment 79% ingested (swallowed) the hook, and 58% were hooked in the beak, tongue, or mouth. Only 3 of the 142 loggerhead turtles were entangled. No attempt was made to remove ingested hooks. Sixty-six percent of mouth hooks were removed, 100% of external hooks were removed, and all line was removed from 77 turtles. The information provided during this experiment will be used to develop improved protocols for removing gear from loggerhead turtles. New procedures and equipment will be evaluated in 2002 experiments.

Figure 15. Hook locations in loggerhead turtles.

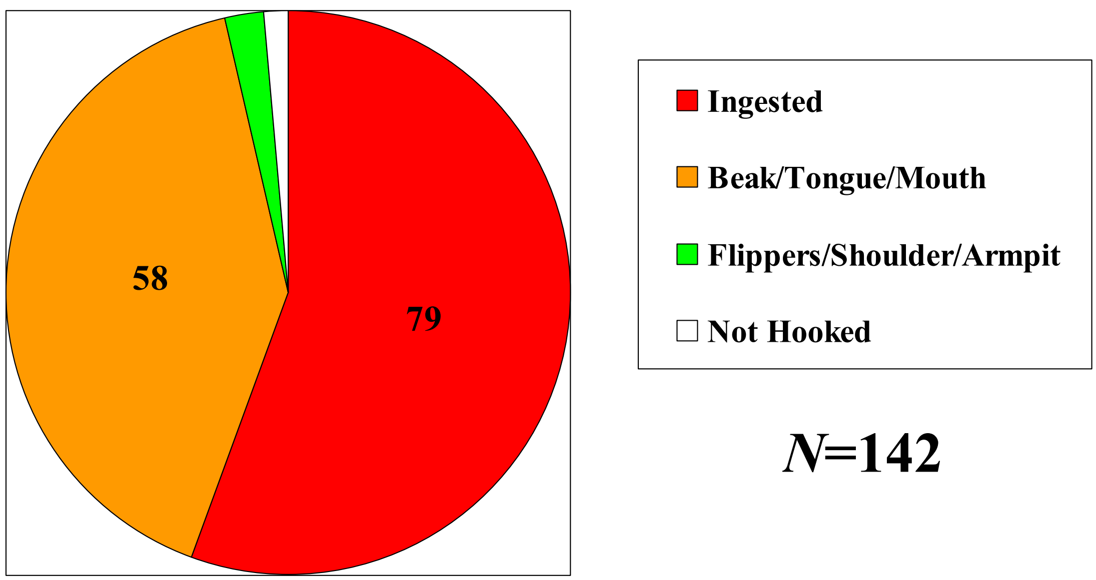
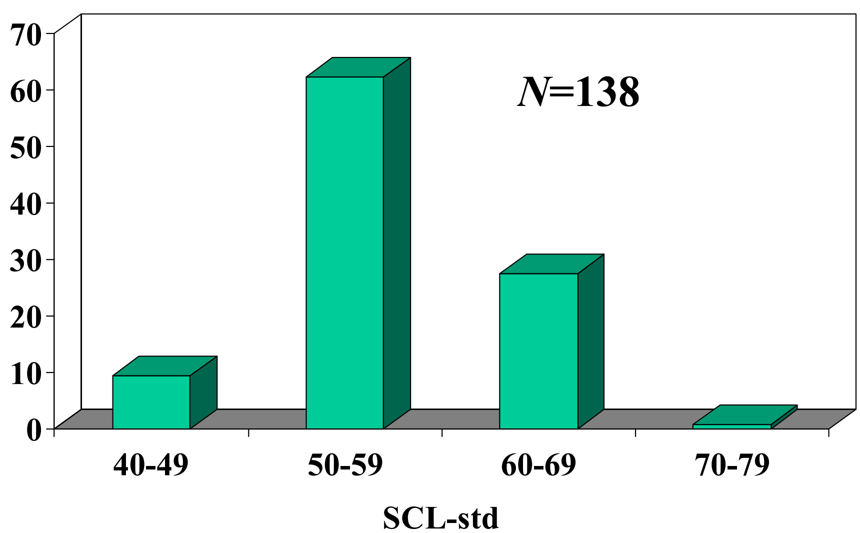


Figure 16 shows the size frequency of the loggerheads caught during the 2001 experiments. Based on size, all were sexually immature. The distribution mirrors that of animals transitioning between the oceanic and the coastal benthic environment. Takes in the pelagic longline fishery are the largest animals in the oceanic environment.

Figure 16. LOGGERHEAD SIZE FREQUENCY (%)



Genetics

Seven mtDNA haplotypes have been identified from genetic sampling for the 119 NED samples processed to date. Mixed stock analyses of the haplotype frequency data indicates that the majority are from the South Florida loggerhead turtle subpopulation, with some originating from the Northern USA and Mexico (Table 3.)

Table 3: Mean estimated stock mixtures of NED loggerhead bycatch based on Bayesian analysis from 1000 resamplings of 4 stock mixtures composed of loggerheads from 4 major nesting stocks. Median and 95% confidence limits (2.5% and 97.5% quantiles) are shown.

Nesting Stock	Mean	Standard Dev	Median	Lower quantile	Upper quantile
North East USA	0.052	0.073	0.018	0.000	0.262
South Florida	0.880	0.102	0.911	0.587	0.985
Mexico	0.066	0.051	0.053	0.007	0.205
Brazil	0.002	0.005	0.000	0.000	0.016

Post Hooking Survival Study

A pilot post hooking survival study is being conduced by NMFS and the University of Florida Archie Carr Center for Sea Turtle Research in conjunction with the longline mitigation experiments. The pilot study is designed to determine the feasibility of using pop-up archival transmitting tags for estimating loggerhead turtle post hooking survival rates (Figure 17). To date, 8 of 16 tags released during the 2001 NED experiments transmitted prior to the programmed pop-off dates indicating that the tags had become free of the turtles. With rare exception the straight-line track between release and pop-up locations showed movements towards the southwest and sometimes significant distances had been covered (Figure 18). Data from 7 tags (insufficient data were provided by the 8th) indicate that the perceived constant depth that initiated the premature release sequence was 0 m, the surface, and that none had dives below 600 m, which would have indicated the turtle had died and was sinking into the abyss. The details of the experimental design, as well as a discussion of the results to date, are given in Appendix IV.

Figure 17. Pop-up Archival Transmitting (PAT) tag attached to a loggerhead turtle released on September 25, 2001 (PTT ID=16299).

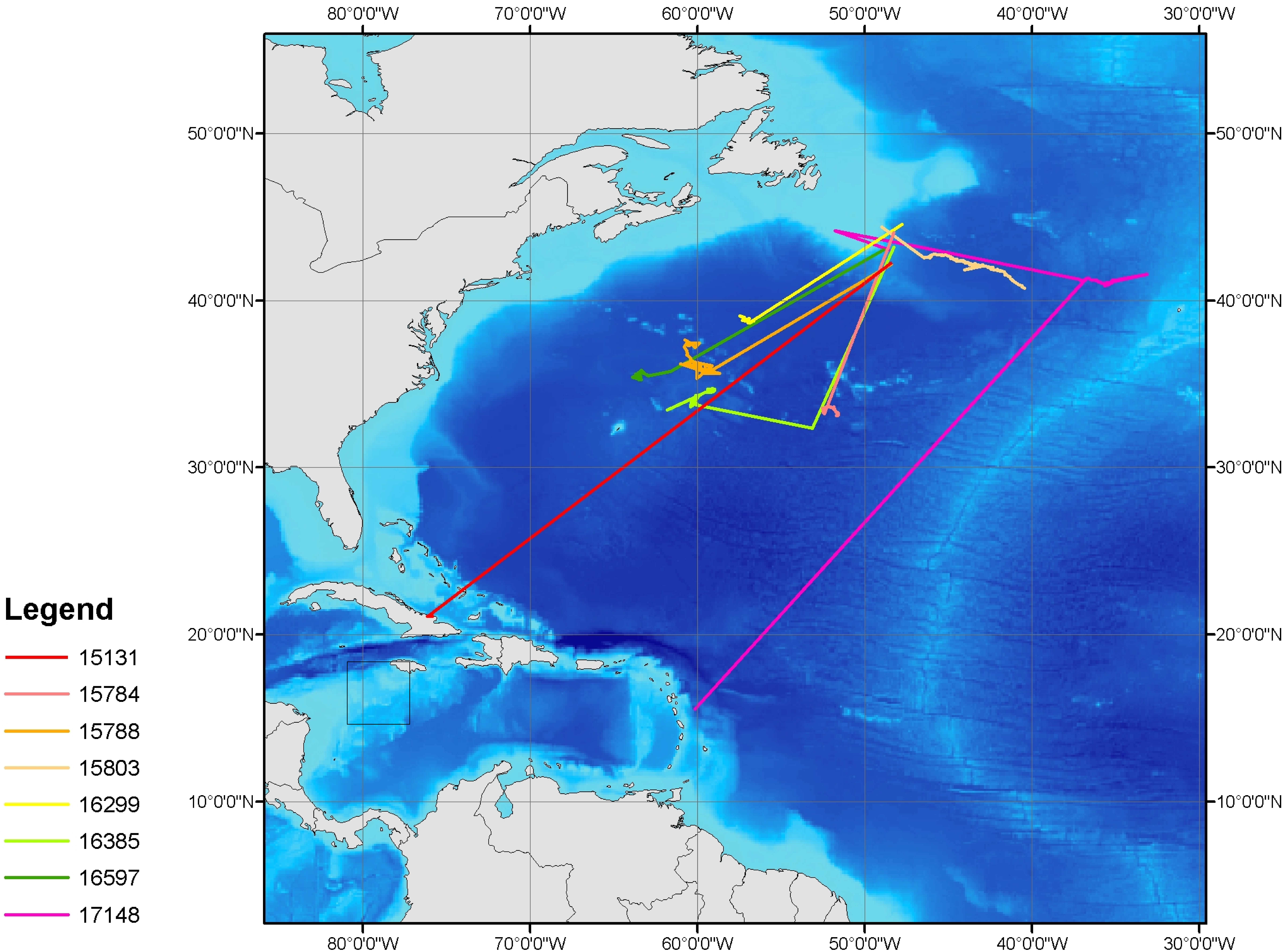


Figure 18. Tagging and transmitting locations for 8 PAT tags.

Proposed Design for 2002 Experiments in the NED

The results of experiments conducted in 2001 reported here have indicated that blue dyed bait and 20 fathom off float hook position are ineffective in reducing sea turtle interaction with longline gear. Analysis of data collected in 2001 indicates that reduced daylight soak time has potential to significantly reduce loggerhead interaction with longline gear. Anecdotal information from the U.S. longline fishery and a recent report from the Canadian longline fishery indicate that mackerel bait has potential to reduce interaction of sea turtles with longline gear. Studies on hook design indicate that circle hooks are effective in reducing deep ingestion of hooks by loggerhead turtles (Bolten et al, 2002 unpublished report) and circle hook designs have the potential to reduce leatherback foul hooking (2001 Canadian report, unpublished). The combination of circle hooks and mackerel bait has the potential to reduce leatherback foul hooking and loggerhead interaction with longline gear and deep ingestion of hooks. The ad hoc pelagic longline advisory group met in Miami on March 12, 2002. The advisory group reviewed the results of the 2001 research and recommended research priorities for 2002 research.

Based on the recommendations of the longline advisory group an experimental design has been developed for 2002 research in the NED. The experimental design will be to; 1) Evaluate the effect of daylight soak time on turtle CPUE 2) evaluate the effect of 0° offset and 10° offset 18/0 circle hook designs with squid bait on turtle CPUE and rate of deep ingestion and 3) evaluate the effect of standard J offset hooks and 10° offset 18/0 circle hooks with mackerel bait on turtle CPUE and rate of deep ingestion. The experimental design for 2002 research in presented in Appendix V.

Acknowledgements

The successful accomplishment of the 2001 experiments reported in this document is the direct result of the extraordinary efforts of the following individuals.

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Sari Kiraly	Bruce Morehead	Christopher Boggs
Christopher Rogers	Larry Beerkerher	Juan Levesque
Georg Hinterigger	Jimmy Rollo	Dick Wurster
Jeff Trew	Peter Dutton	

Industry:

Dan Shawhand	Mike Swann	Scott Drabinowicz
John Caldwell	George Smith	Jim Flagel
Larry Horne	Jimmy Mears	Jim Budi
Nelson Beideman	Peter Lingren	Shawn Dick
Don Nehls		

University:

Alan Bolten
Brian Riewald

Contractors:

Charles Bergmann
Nick Hopkins
Jeff Hoffman
Daniel Lawson
Patrick Rice
Warren Mitchell
Lisa Csuzdi
Dina Aly
Kimberly Blair

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Appendix I. Report of the April, 2001 Meeting to Plan Pelagic Sea Turtle Mitigation Experiments in the Western Atlantic Ocean.

Report of the Meeting to Plan Pelagic Sea Turtle Mitigation Experiments in the Western Atlantic Ocean Grand Banks (NED) Area

John W. Watson

April 19 - 20, 2001
Miami, Florida

United States Department of Commerce
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Southeast Fisheries Science Center

Report of the Meeting to Plan Pelagic Sea Turtle Mitigation Experiments in the Western Atlantic Ocean Grand Banks (NED) Area

April 19 – 20, 2001
Miami, Florida

Welcome and Introduction

John Watson, Team Leader, Harvesting Systems Team, Mississippi Laboratories, Southeast Fisheries Science Center, National Marine Fisheries Service called the meeting to order at 9:00 AM on Thursday, April 19. Dennis Lee, Research Fisheries Biologist, Sustainable Fisheries Division, National Marine Fisheries Service, Miami Laboratory welcomed the participants to the Miami Laboratory. The participants were introduced and Mr. Watson outlined the objective of the meeting and reviewed the agenda and handout materials.

Objective

The objective of the meeting was to plan and prioritize experiments in the Western Atlantic Ocean Northeast Distant Area (NED) investigating the effectiveness of mitigation measures to reduce the incidental take and mortality of sea turtles by pelagic longline gear and to coordinate efforts in the Western Atlantic with efforts in the Pacific and Azores.

Background

A draft proposal to conduct experiments in the Atlantic Northeast distant waters (Grand Banks) area to evaluate sea turtle mitigation measures (Appendix 3) was sent to all of the participants for review prior to the meeting. This document has been revised based on the results of this meeting. In order to provide background information necessary to coordinate research in the Western Atlantic with efforts in the Pacific and Azores presentations were made by Christopher Boggs (NMFS Honolulu Laboratory) and Alan Bolten (University of Florida).

Dr. Boggs gave a brief summary of the research planned by the NMFS Honolulu Laboratory. The Hawaii based swordfish fishery is closed except for research on sea turtle mitigation techniques that will be conducted under an Endangered Species Act section 10 permit. The research will include experiments to test minor changes in gear and tactics and research to evaluate major changes in fishing gear and tactics. Fishermen will participate in experiments and will be compensated for catch loss when conducting experiments to evaluate minor changes in gear and tactics. Research that requires major changes in fishing gear and tactics may be conducted on chartered commercial vessels. Scientific research technicians will collect data on board commercial fishing vessels. Research planned for 2001 includes testing three mitigation techniques in combination. These techniques include the use of blue-dyed squid bait, moving branch lines more than

40 fathoms away from floats, and moving fishing operations more than 30 nautical miles from locations of turtle captures. These mitigation techniques are expected to have minimum impact on catch of target species. The blue dyed bait mitigation technique is the most popular among Hawaii based fishermen. It was suggested that blue and natural squid bait be alternated within a set. Some discussion followed on this suggestion. Dr. Boggs indicated that the bait might broadcast signals that would cause interaction between the bait types. His preference is to alternate sets with blue dyed and natural squid baits.

Other research planned by the NMFS Honolulu Laboratory includes the development and testing of stealth gear, evaluation of deep daytime fishing for swordfish, determination of time and depth of turtle interaction with longline gear, and testing modified hook designs. These measures are considered major changes in fishing gear and techniques and may have significant impact on catch of target species. Don Nehls and Keith Larson reported that they had tried on many occasions to fish deeper for swordfish during daylight hours with no success. Dr. Boggs indicated that this was useful information and requested more detail on their efforts and results. There was some discussion on setting times and the possible effect on turtle interactions. Data on when turtles bite hooks using hook timers was felt to be important information that could determine the potential of altering setting times as a mitigation measure. Stealth gear designs discussed were counter-shaded floats, dark colored main lines, dulled hardware, dyed baits, and down-facing LED lightsticks.

Alan Bolten then presented a summary of the research conducted in the Azores in 2000 and research planned for 2001. Dr. Bolten's research involved testing three types of hooks: straight J (9/0), reversed/offset J (9/0), and circle (16/0). Dr. Bolten indicated that the size turtles encountered by longline gear in the Azores swordfish fishery ranged between 45 and 65 cm in length. The sizes of turtles, which inhabit the area, are between 10 and 65 cm in length. A total of 237 turtles were captured during the study between July 15 and December 15, 2000. The catch rate was calculated as 2.5 turtles per set (1.7 turtles per 1000 hooks). There was no significant difference in the total numbers of turtles caught by each hook type, but there was a significant difference among the 3 hook types in the location of hooks in the turtles. For loggerhead turtles 57% caught on J hooks were hooked in the throat, 81% of the loggerheads caught on circle hooks were hooked in the mouth. There was a significant difference among the hook types in the numbers of swordfish caught. The circle hook caught 262 swordfish compared with 381 for the J hook.

Dr. Bolten then presented options for testing in 2001 and opened discussion on which option should receive the highest priority. Options discussed included larger circle hooks (18/0 or 20/0), squid versus mackerel bait, light sticks, dyed bait, and effect of stiff leaders. Discussion of differences in gear configuration between Azores and other areas followed. There are significant differences in the materials used to construct gear in the Azores and U.S. fisheries and there are differences in the configuration of the gear. It was felt by commercial fishermen that Azores gear would tend to fish shallower than U.S. gear due to buoyancy of materials and configurations used. It was felt that hook studies conducted in the Azores would be transferable to other areas and research should concentrate on this type of study. It was also suggested that due to the high rate of turtle captures in the Azores, testing for turtle reduction could be done in the Azores and testing for efficiency in maintaining target catch rates could be conducted in other areas. There was considerable discussion on hook designs. The participants felt that the highest priority for Azores work should be testing 18/0 circle hooks followed by mackerel and blue dyed bait studies. Testing the 18/0 circle hook will determine if the increase distance between the shank and the tip over the 16/0 circle hook will increase efficiency for swordfish catch while maintaining reduction in deep (throat hooking) and upper jaw hooking of turtles.

Nelson Beideman then read a statement from the Blue Water Fishermen's Association. In his statement Mr. Beideman recognized the importance and value of efforts to develop innovative means to reduce sea turtle interactions with pelagic longline gear and to reduce the mortality of turtles, which are caught by longline gear. He expressed willingness of the industry to conduct "voluntary" experiments on solutions that can be promoted internationally. He then stated that "the industry must resist involuntary experiments imposed as a consequence of politics rather than valid science." He stated that under the context of a "jeopardy finding" under the Endangered Species Act that their fishery could not participate in the meeting in this forum and would not be returning to the meeting after the morning break. He further stated that their fishermen could not accept the finding set forth in the NMFS draft Biological Opinion that their fishery is "likely to jeopardize the continued existence" of Atlantic loggerhead and leatherback sea turtles. The full text of Mr. Beideman's statement on behalf of the Bluewater Fishermen's Association is presented in Appendix 4 of this report. Mr. Beideman submitted several documents in support of their position that are attached in Appendix 4.

Gerry Scott and John Watson then expressed their understanding of the fishermen's concerns and position but that the objective of this meeting was to plan research and that there are other mechanisms and forums in place for addressing their concerns. Mr. Watson expressed concern that we would be missing the opportunity to have the input of the industry in research planning if they did not participate and that their participation is critical to developing effective solutions to the problem. He also expressed concern that many people had devoted time and expense to travel to Miami to participate in the meeting and valuable resources would be wasted if we did not continue with the planning process. Mr. Watson in consultation with Dr. Scott then suggested that the planned agenda be modified so that the draft experimental design could be presented to the industry before they departed the meeting. The industry members present agreed to the agenda modification and agreed to meet in an informal setting after the meeting to provide input into research priorities. Mr. Beideman also provided a review of the draft experimental design for inclusion in the proceedings.

John Watson then made a presentation on the draft experimental design to investigate sea turtle mitigation measures on the Grand Banks. Mr. Watson first presented the results of the meeting held April 4-5, 2001 in Pascagoula, MS with industry members, and scientist from the Southeast and Southwest Fisheries Science Centers. The purpose of the prior meeting was to plan fisheries independent research in 2001. This research is designed to develop ideas and conduct preliminary investigations of possible mitigation techniques using captive reared turtles and research vessels. This research will determine the potential of possible mitigation techniques prior to fishery dependant research efforts.

Research priorities for fishery independent research are:

- Investigate sea turtle attraction to longline floats
- Determine effect of float color on sea turtle behavior
- Investigate chemical deterrents
- Evaluate stiffer drop lines and gangions
- Evaluate hook guards and bait holders
- Investigate sea turtle predator avoidance behavior
- Evaluate blue dyed baits and squid ink with loggerhead turtles
- Evaluate corrodible hook designs

Mr. Watson then presented a list of possible experiments that could be conducted in the Western Atlantic on cooperative or chartered commercial vessels in 2001. The list of possible experiments is:

- Evaluate effectiveness of dip nets, line cutters, and de-hooking devices in reducing sea turtle mortality.
- Moving hooks at least twice the length of gangions from floats
- Moving fishing operations when turtle interactions occur
- Using blue dyed squid bait
- Fish cooler water (SST limit)
- Determine when turtles are caught (hook timers)
- Record turtle and swordfish behavioral interaction with longline gear
- Use mackerel bait

The estimated potential of proposed mitigation techniques was then presented including the potential to reduce sea turtle interactions and injury and mortality and the potential to retain target catch. Mr. Watson then presented information on the anticipated fishing effort in the Grand Banks area (NED) in 2001 and sample sizes required to evaluate potential mitigation measures estimated from observer data.

The meeting was then adjourned for the day and an informal discussion held at the Hampton Inn hotel with members of the fishing industry. The industry representatives discussed their priorities for NED experiments provided their concerns over the findings set forth in the NMFS draft Biological Opinion can be resolved. Their first priority would be to determine the effectiveness of mitigation measures already in place including estimating the reduction in sea turtle mortality rate achieved through the use of dip nets, line cutters, and de-hooking devices. The industry representative's second priority would be to establish real time communications within the fishing fleet that would allow avoidance of areas of turtle interactions. They felt that the Azores work on circle hooks was a high priority and that priorities for experiments in the NED should be to test; blue dyed squid bait, mackerel bait, moving hooks from floats, stiffer buoy lines and gangions, and offset circle hooks in order of priority. The industry members present also were concerned that loss in target catch during experiments be compensated and considerable discussion followed on level of compensation that would be considered appropriate by the industry.

There was some discussion on the feasibility of determining the effectiveness of gear removal on post hooking mortality using satellite tags. Several researchers with tagging experience indicated that while satellite technology is improving there are still many limitations and problems with this technology and the sample sizes required to determine post-hooking mortality might be cost prohibitive. It was suggested that some preliminary investigations using satellite tags and in particular the new Pop-Up Satellite Archival Tags (PSATs) could be conducted to determine the feasibility of determining post hooking mortality rates. The NMFS Honolulu Laboratory is conducting experiments with PSATs using a new attachment procedure and similar experiments could be conducted in the NED. After further discussion it was suggested that the priorities for research in the NED be divided into long-term and short-term research. The long-term research priorities would be to investigate methods of estimating the effectiveness of removing gear from turtles after encountering longlines in reducing mortalities and the development of communications to allow fishermen to avoid areas of sea turtle interaction. The short-term research would be to test blue dyed squid baits, mackerel baits, moving hooks from floats, stiffer buoy lines and gangions, and offset circle hooks.

On Friday April 20, at 9:00 AM the meeting resumed without the attendance of the industry representatives. Dennis Lee gave a brief presentation on the vessels that are likely to fish in the NED in 2001. Discussion followed on details of setting up experiments, the observer program, data collection requirements, and observer capabilities.

Cheryl Ryder then gave a presentation on research planned to investigate turtle life history in the NED using satellite tags in 2001. The Northeast Fisheries Science Center has received funding to conduct a study on the movements, behavior and habitat preference of turtles relative to longline target species on the Grand Banks. The purpose of this study is to better understand the population structure and life history of loggerhead turtles on the Grand Banks. The objectives of this study are:

1. To determine the genetic stock identification of loggerheads on the Grand Banks
2. To tag up to 10 pelagic stage loggerhead turtles with satellite TDRs to produce statistically valid results on their behavior and ecology on the Grand Banks
3. To utilize GIS techniques to evaluate turtle movements relative to temperature, currents, productivity and other oceanographic correlates

Data relayed by satellite from each turtle instrumented will include:

- Global position
- Dive depth profiles
- Dive duration profiles
- Surface and submergence activity profiles
- Water Temperature

Discussion followed on the requirements of placing tags on turtles by observers or fishery technicians, tag attachment methods and the state of satellite tagging technology.

There was further discussion on details of experimental design for sea turtle mitigation research in the Azores, Hawaii, and the NED before the meeting was adjourned.

Agenda

Thursday Morning, April 19, 2001

9:00	Welcome, introduction of attendees – John Watson
9:10	Charge to participants - John Watson
9:15	Pacific research – Chris Boggs
9:30	Azores research – Alan Bolten
9:45	Grand Banks research – Cheryl Ryder
10:00	Industry perspective – Nelson Beideman
10:15	Requirements under the Endangered Species Act – Section 7 Consultation Draft Biological Opinion for Atlantic Highly Migratory Species – Barbara Schroeder
10:30	NED vessels – Dennis Lee
10:45	Break
11:00	Draft experimental design to investigate sea turtle mitigation measures in the Grand Banks (NED) – John Watson
11:45	Lunch

Thursday Afternoon, April 19, 2001

1:00	Discussion of draft experimental design and prioritization of experiments - Participants
2:30	Break
2:45	Suggested modification of experimental designs based on participant input and discussion - Participants
6:00	Adjourn

Friday Morning, April 10, 2001

8:30	Additional discussion and planning - Participants
11:30	Adjourn

List of Participants

Name	Organization
Nelson Beideman	Blue Water Fisherman's Association
David Bernhart	NMFS, Southeast Regional Office
Christopher Boggs	NMFS, Southwest Fisheries Science Center
Alan Bolten	University of Florida
Charlie DiPesa	F/V Destiny
Sherry Epperly	NMFS, Southeast Fisheries Science Center
Nick Hopkins	Johnson Controls
Anne Lange	NMFS, Highly Migratory Species Division
Keith Larson	F/V Karen-L, F/V Lori-L, F/V John de Wolf
Dennis Lee	NMFS, Southeast Fisheries Science Center
Peter Lindgren	Lingren- Pitman Inc.
Don Nehls	Lingren – Pitman Inc.
Cheryl Ryder	NMFS – Woods Hole, MA
Barbara Schroeder	NMFS – Silver Springs, MD
Jerry Scott	NMFS – Southeast Fisheries Science Center
John Watson	NMFS – Southeast Fisheries Science Center

Appendix II. Proposal to Conduct Experiments in the Western Atlantic Northeast Distant Waters (Grand Banks) Area to Evaluate Seat Turtle Mitigation Measures.

PROPOSAL TO CONDUCT EXPERIMENTS IN THE WESTERN ATLANTIC NORTHEAST DISTANT WATERS (GRAND BANKS) AREA TO EVALUATE SEA TURTLE MITIGATION MEASURES

JULY 2001

United States Department of Commerce
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Southeast Fisheries Science Center

PROPOSAL TO CONDUCT EXPERIMENTS IN THE WESTERN ATLANTIC NORTHEAST DISTANT WATERS (GRAND BANKS) AREA TO EVALUATE SEA TURTLE MITIGATION MEASURES

Background

Incidental capture of sea turtles in fisheries is one of the most significant threats to their survival and recovery. Possible management measures addressing the incidental take and mortalities of endangered and threatened sea turtle species by U.S. pelagic longline fisheries include research to design, develop, and evaluate gear and/or tactical measures capable of significantly reducing the interaction between sea turtles and longline fishing gear. Pelagic longline fleets of other nations comprise over 90% of the longline fishing effort in the Atlantic. A major emphasis of the U.S. gear development research effort will be to transfer successful technology and encourage the use of practical measures to reduce sea turtle interactions by foreign fleets.

Pelagic longline fisheries that affect U.S. sea turtle populations occur in the Eastern and Western Pacific Ocean, Western Atlantic Ocean, Azores, Caribbean, and Gulf of Mexico. Fishery dependent research to develop and test sea turtle mitigation measures is being conducted in the Western Pacific (Hawaii fishery) by the NMFS Honolulu Laboratory (Boggs, 2000), the Azores (Bolten and Bjorndal, 2000), California (La Grange, 2000), and is planned for the Western Atlantic (Watson, 2001a), and Mexico (Boggs per.comm.). Fishery independent research using captive reared turtles, research vessels, and/or contract commercial vessels is also being planned (Watson, 2001a). These various research efforts are being coordinated and cooperative research planned to provide collective expertise and collaboration in order to solve this complex problem. Although there are differences in environmental conditions, gear, and fishing tactics used among the different fisheries, there are common factors that can be evaluated and success in any area will lead to evaluation in other areas with some solutions effective across differences. A meeting was held in April 2001 in Miami Florida to provide coordination of the research efforts in the Pacific, Atlantic, and Azores (Watson, 2001b).

Several industry/academia/government workshops have been held to address possible gear and or fishing tactic modifications with potential to reduce sea turtle interactions with pelagic longline gear (Williams et al, 1994; Kleiber and Boggs, 1999; Anon., 2000; Anon., 2001a; Watson, 2001b). Pelagic longline observer data have been analyzed to examine gear, environmental, and operating practices associated with sea turtle longline interactions (Kleiber, 1998; McCracken, 2000; Cramer and Adams, 2000; Hoey, 1998, 1999, 2000 and Yeung, 2001). The information from these reports is the basis for current and planned research to develop and evaluate potential mitigation measures. A major component of this research is to conduct cooperative experiments with commercial pelagic longline vessels in the Pacific and Atlantic fisheries. This document outlines a research plan for the Grand Banks area in the Western North Atlantic and outlines cooperative research effort in the Pacific and Atlantic.

METHODOLOGY

Research will involve experiments using commercial vessels to evaluate the potential of candidate mitigation measures under actual fishing conditions and will be designed to estimate the reduction in turtle interactions and injury and impact on target species. This research will be conducted in coordination with concurrent research in other fisheries and with fishery independent studies in order to systematically investigate effectiveness of candidate measures and utilize available resources in the most effective manner. To achieve this goal, potential mitigation measures from reports cited above have been evaluated as to their potential effectiveness based on available knowledge and placed into a matrix outlining the initial methods of evaluation (table 1). The matrix lists possible mitigation measures for initial evaluations with commercial vessels and measures that require fishery independent research to determine potential or to develop more precise methodology before testing in commercial fishing operations. The matrix is designed to best utilize resources to achieve effective results. As research results become available mitigation measures will be moved within the matrix as the results indicate. For example, if fishery independent research demonstrates a potentially highly effective measure it will be moved into fishery dependant evaluation and if measures appear ineffective in fishery dependent studies they may be dropped from the research matrix. New measures will be added to the matrix as they are developed. A pelagic longline gear-working group consisting of gear researchers, fishery managers and fishers has been established to make recommendations regarding the priority and method of evaluations.

The estimated potential effectiveness of the mitigation measures proposed for research based on current knowledge is given in table 2. Methods proposed for testing in the Western North Atlantic Grand Banks fishery are those for which potential effectiveness has been indicated by observer data and fishers experience that require evaluation in terms of turtle take reduction and effect on target species catch rates in commercial fishing operations. Other methods are proposed to be initially investigated using captive reared turtles in field experiments and wild turtles using research and/or contract vessels. A key component of this research will be to determine the behavior of target species when interacting with longline gear. This will be accomplished with the NMFS Mississippi Laboratories research vessel (HST-1) using video camera systems specifically designed for use with longline gear in the Desoto Canyon area of the Gulf of Mexico.

The fishery dependent experimental design will be to test potential turtle bycatch reduction techniques (treatments) against standard fishing practices (control) by alternating sets or alternating treatment and control within a set depending on the nature of the methods being tested. The limiting factors associated with the experimental design that will determine how many treatments can be tested in a given year are the total effort (number of vessels, number of trips, number of sets per trip, number of hooks per set) and the number of hooks or sets required to provide statistically significant estimates of turtle take reduction rates.

In order to provide an estimate of the effort required, observer data collected by the NMFS Southeast and Northeast Fisheries Science Centers in the northeast distant area (NED) from 1991- 1999 were analyzed to estimate the sea turtle CPUE. The total number of turtles taken by longline gear on observed sets between 1991 and 1999 was 376; the number of hooks fished on observed sets was 303,089. The number of loggerhead turtles taken on observed sets was 249, and the number of leatherbacks was 117. CPUE values were 0.00124 for total turtles, 0.00082 for loggerhead turtles and 0.00038 for leatherbacks. For the most recent year available (1999), the total number of turtles taken on observed sets was 76, loggerhead turtles 44, and leatherback turtles 32 for 32237 hooks fished. CPUE values were 0.00235 for total turtles, 0.00136 for loggerheads, and 0.00099 for leatherbacks. Sample size computations, controlling for Type I and Type II errors at pre-specified levels, to detect a reduction of 25% and 50% in turtle CPUE due to treatment effectiveness were performed using the arcsine square root transformation. These computations were done using the 1991 to 1999 series data and 1999 data only. The burden of proof is placed on the treatment being tested and hence the experiment null hypothesis states that the control capture proportion is less than or equal to the corresponding treatment proportion.

For all experiments the effect on the directed take (swordfish) CPUE will be calculated to determine the impact on the fishery of the turtle mitigation measure being evaluated. This proposal includes a request for funding to compensate cooperative commercial vessels participating in the experiments for loss in revenues due to the experiments. The level of compensation will be negotiated with the Blue Water Fishermen's Association, participating vessel owners, and captains and negotiations will be conducted with Blue Water Fishermen's Association to provide for disbursements of compensation funds.

Fishing effort for 2001 was estimated based on logbook data and interviews with the longline industry. During 2001, it is anticipated that between 8 and 15 vessels could fish in the Grand Banks, making an average of 4 trips per vessel. It is estimated that each vessel will make between 14 and 20 sets per trip with an average of 806 hooks per set. Each vessel would be expected to set between 11,284 and 16,120 hooks per trip and between 45,136 and 64,480 hooks per season. If 10 vessels fish the maximum number of hooks the total effort would be 640,480 hooks.

POSSIBLE TREATMENTS FOR GRAND BANKS EXPERIMENTS IN 2001

Effectiveness of dip nets, line cutters, and de-hookers

The harvestings systems and engineering branch and commercial fishers are developing line cutters and de-hookers that will help remove longline gear from turtles hooked or entangled. In 2000 some vessels used dip nets provided by the SEFSC observer program to bring turtles onboard to remove longline gear. The removal of longline gear from turtles that interact with pelagic longline gear is likely to significantly decrease mortality. Recent observations from the Mediterranean indicate that a higher percentage of post-hooking mortality is caused by monofilament left attached to turtles than by deep hooking (Aquirre, pers. comm.). New line cutting gear being developed will allow removal of gear in water for turtles too large to bring on board. Turtle handling procedures will be developed using de-hooker devices and the effectiveness of all procedures and tools evaluated by observers and vessels crews. Observers will record detailed information onto data forms about the turtle interaction including whether the turtle was hooked and/or entangled, where the turtle was hooked and/or entangled, procedure used to remove gear and condition of turtle upon release. Some turtles may be fitted with pop-up satellite transmitting archival tags (PSTATs) to quantify survivorship of marine turtles after release from encounters with longline gear and the effectiveness of handling and gear removal techniques. Turtles will also be tagged with conventional flipper tags and biopsy tissue samples collected. This research was considered the top priority by representatives of the commercial fishing industry at the gear working group meeting held in Miami FL April 19-20, 2001 (Watson, 2001b).

Use of blue dyed squid / mackerel bait

Research in Hawaii has shown that blue dyed squids reduce the bycatch of seabirds and possibly increase the catch of swordfish. When field-testing blue bait on seabirds no turtles were caught while turtles were caught with normal bait during the study (anon, 2000). Laboratory tests have shown that green turtles are reluctant to take blue dyed squid compared to normal squid, but eventually habituate to dyed bait (Brill, pers. comm.). The NMFS Galveston Texas Laboratory will conduct laboratory test on colored squid baits with loggerhead turtles to compliment the Hawaii studies. The NMFS Honolulu laboratory will conduct test on commercial longline vessels in 2001 using blue dyed squid and it was the consensus of the gear-working group that evaluation of blue dyed squid should be the 1st priority for experiments in the NED in 2001. Complementary research on this treatment in both Hawaii and the NED will provide sufficient data in 2001 to determine the effectiveness of this mitigation technique.

Commercial fishermen have observed reduced turtle takes when using mackerel for longline bait as compared to squid. Evaluation of mackerel bait in comparison with squid bait was the 2nd priority for evaluation in the NED in 2001 by the members of the gear-working group.

Hook proximity to floats

An important effect of hook configuration for swordfish longline gear is that both loggerhead and leatherback turtles are caught with a significantly greater frequency on hooks adjacent to the floats in the Hawaii-based fishery (Kleiber and Boggs 2000). Hawaii and Atlantic (Beideman, pers. comm.) longline fishers fishing for swordfish typically using 3-5 hooks between floats, place one branch line (hook) on the main line as close as possible after attaching the float line, which makes that the shallowest hook position as well as the position closest to the float. A preliminary analysis of data on swordfish caught in the Hawaii-based fishery by Pierre Kleiber (pers. comm.) indicates that the distribution of hooks that caught swordfish was not much different from the distribution of all hooks available to the swordfish. Hooks adjacent to floats did not appear to have a higher swordfish catch rate compared to other hook positions. However, Atlantic swordfish fishers add the hook adjacent to the float line because they believe that the action imparted to the hook by wave motion makes the bait presentation more attractive to swordfish. Historical observer data from the Atlantic does not include information on the position of hooks that caught turtles. Evaluation of the effect of moving branch lines away from float lines on turtle interaction rates was proposed as the 3rd priority for evaluation in the NED in 2001 by the gear working group.

Stiffer buoy and branch lines

Observer data indicates that for leatherback turtles entanglement in buoy and branch lines is the predominant interaction with longline gear. It has been proposed that stiffer buoy and branch lines may be effective in reducing entanglement. The gear-working group identified the use of stiffer buoy and branch lines as the 4th highest priority for research. Data on the fishing characteristics and potential of different diameters and weighing is needed before designing an experiment on commercial vessels to test this mitigation measure. NMFS and industry representatives will evaluate stiffer buoy and branch lines in June 2001 using captive reared turtles and the R/V HST-1 to determine the potential of different combinations of line diameter and weighting. The results of this research will be used to design gear for evaluation in the NED.

Offset circle hooks

Dr. Alan Bolten (University of Florida) has conducted research in the Azores on the effectiveness of circle hooks for reducing sea turtle injury and mortality (Watson, 2001b). Dr. Bolton's research found that the use of 16/0 circle hooks reduced throat hooking compared to standard J hooks but also reduced swordfish catches. Dr. Bolten is proposing to evaluate a larger 18/0 circle hook in 2001. The gear review panel suggested that an offset circle hook may be more effective in retaining swordfish catch rates and proposed this hook design be evaluated in the NED. This experiment was ranked 5th in order of priority for NED research.

Move away from interactions

Observed takes of sea turtles (all species combined) in the Atlantic Fishery show clear evidence of aggregation, that is, the incidence of taking several turtles on one set was six times higher than expected due to chance based on rates given by Hoey (NMFS, Contract Report). About 7% of sets interacted with a single turtle so the expectation that two wouldn't be caught together due to chance is only about 0.5%. Turtle aggregation appears to be even more pronounced in the Grand Banks portion of the fishery, where 5% of the sets observed accounted for over 50% of the turtles taken. This result and the experience of many fishermen suggest that avoidance of the areas of sea turtle aggregation could reduce turtle takes. Moving fishing operations away from an area where turtle interactions occur could be a highly effective measure for reducing takes, but regulatory definition and enforcement would be very difficult. Industry representatives suggested that efforts be made to establish real time communications within the fishing fleet that would allow avoidance of areas of turtle interactions.

Temperature limit

Evaluation of observer data from the Grand Banks fishery suggests that turtle takes occur more often in waters with a sea surface temperature (SST) >65° F (Hoey, NMFS Contract Report). One treatment for testing would include making equal numbers of sets in waters with SST below 65° F (< 65°, treatment) and in waters with SST at 65° F or above (65°+, control). Witzell et al., 2001 indicates that a more effective SST limit may be 62° F. Longline fishers state that the temperature effect is complex and a simple cutoff in temperature would not necessarily be effective. They propose that they use available information on site to determine setting temperature to avoid turtle interactions. This mitigation technique was not considered practical by the gear-working group and was given a low priority.

Setting time

Loggerhead and Leatherback interactions with longline gear are highest on sets deployed between 4:00 PM and 6:00 PM for the Grand Banks fishery (Hoey, 2000). Analysis of observer data by Hoey, 1998 indicated that there might be a slightly higher sea turtle interaction rate associated with early evening sets as opposed to late evening sets. Delaying start of gear setting may reduce turtle encounters. More data is required to substantiate the merit of this possible mitigation measure. It is proposed that electronic microchip hook timers be attached to branch lines to record times when turtle interactions occur and times when target species are hooked. This technique has been successfully used in the Pacific to resolve the uncertainty in estimating capture depths and times of fish on pelagic gear (Boggs, 1992).

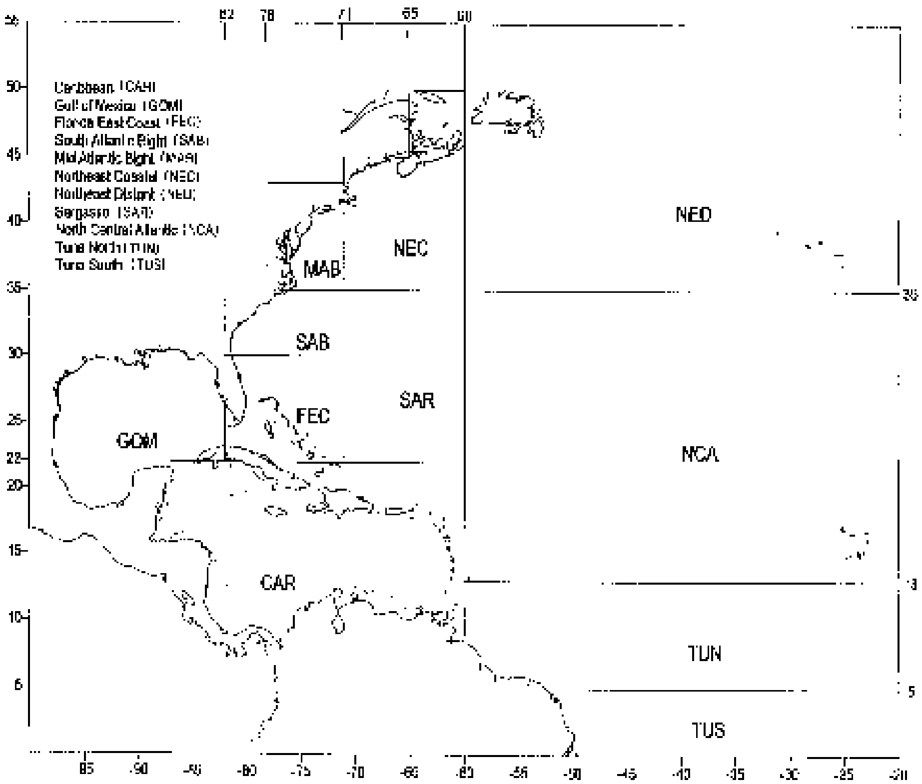
Sea turtle and swordfish behavior

Gear researchers and fishers have proposed a suite of possible mitigation techniques for which there is very little or no data to indicate possible effectiveness. These techniques include; use of stealth gear (counter shaded floats, colored mono, hooded light sticks), modified hook designs, hook guards, and turtle deterrents and or attractors. These techniques will be evaluated in other fishery dependant research (Azores) and thorough fishery independent research in the Pacific, Atlantic, and Gulf of Mexico. The successful development of conservation gear has historically been dependant on a through knowledge of animal behavior in relation to fishing gear (Ogren, et al, 1977; Watson, 1989). Knowledge of turtle and target species behavior in relation to longline gear can greatly expedite the development of effective mitigation techniques. Specialized camera systems are being developed that will enable video recording of turtle behavior in and around longline gear including floats, drop lines, mainline and branch lines. The same equipment will record target species behavior when encountering longline gear. The camera systems will be used to record behavior and interaction with specific mitigation measures listed above and will expedite decisions on which techniques to evaluate on commercial vessels. The camera systems will be evaluated on NMFS research vessels and may be provided to commercial fishers to record and document turtle and swordfish behavior interactions with fishing gear. These cameras will also be made available to researchers in other areas including the Azores and Pacific.

PROPOSED 2001 EXPERIMENTAL DESIGN FOR THE GRAND BANKS (NED)

The National Marine Fisheries Service proposes to conduct scientific research in consultation and cooperation with the domestic pelagic longline fleet in the Western North Atlantic to develop and evaluate the efficacy of new technologies and changes in fishing practices to reduce the incidental take and mortality of endangered and threatened sea turtle species by pelagic longline gear. This research is scheduled to commence by August 1, 2001 and results evaluated after the completion of each fishing season to determine the effectiveness of mitigation measures evaluated. At the completion of 3 years of research, the program will be evaluated and recommendations provided to fishery managers. NMFS is seeking authorization of this research through application of an ESA section 10 research and enhancement permit. The proposed research will utilize domestic fishing vessels as cooperative research platforms in the Northeast Distant (NED) statistical sampling area (Figure 1). Participating U.S. pelagic longline vessels that fish the NED must carry observers, and they must fish their gear in a specified, pre-determined manner designed to test one or more variables affecting sea turtle bycatch.

Figure 1 **Pelagic Longline Fishing Areas** Source: Cramer and Adams, 2000.



Based on the recommendations of the pelagic longline gear working group the priorities for experiments in the NED are:

6. Evaluation of blue dyed squid bait
7. Evaluation of mackerel bait
8. Moving hooks away from floats
9. Stiff buoy lines and gangions
10. Offset circle hooks

The anticipated potential effectiveness of individual mitigation measures to reduce sea turtle interactions based on current knowledge is expected to be between 25% and 50%. It is hoped that combinations of potential mitigation measures will exceed 50%. In order to maximize the benefit of the research effort, evaluation of the highest priority research areas will be conducted simultaneously. The proposed research would simultaneously evaluate three experimental gear configurations against a control treatment.

A power analysis was conducted to estimate the experimental fishing effort required to detect a fishing method that has different degrees of effectiveness in reducing bycatch of turtles in comparison with the control fishing method. The null hypothesis for the experiment was constructed so that the burden of proof is on the treatment to be proven; that is, we initially assume that the treatment is not effective and must prove statistically that it is effective. The factors affecting the required level of effort are the actual sea turtle catch rates and variability, the effectiveness of a measure being tested (*i.e.*, the difference in catch rate between the experimental and control treatments), and the statistical risk of error. We projected the expected sea turtle catch rates based on the average catch rate observed in the Grand Banks fishery over 1991-1999 and using only the higher catch rate in the most recent available year's data (1999). For the expected effectiveness of measures, we looked at 50% and 25% bycatch reduction. We believe that this research should attempt to prove or disprove measures that may have bycatch reductions as low as 25%. We believe that 25% is the minimum acceptable reduction rate that may be useful to sea turtle management and conservation. Reduction rates below 25% would also require an exponential increase in effort to detect. We have set the alpha and beta levels at 10% and 20%, respectively, which are typical levels of statistical risk for this type of gear evaluation experiment. Table 3 shows the results of the power analysis considering these factors, including the required number of hooks for this four treatment experiment.

Table 3. Estimated sample sizes required to conduct proposed bycatch reduction experiment in the Grand Banks longline fishery. Estimates are the result of power analysis that considered the observed CPUE of each species in the Grand Banks as a 9-year average and also the single-year value for 1999. The power analysis was performed to detect bycatch reduction rates, relative to the control, of 25% and 50% with alpha set at 10% and beta set at 20%.

Species	Assumed Sea Turtle Capture Rates	Assumed Bycatch Reduction	# of Hooks Required For Each Treatment	# of Hooks Required for 2 treatments and corresponding Control
Loggerhead	91-99 Average	25%	152,708	**610,832**
Loggerhead	1999 Value	25%	89,585	358,340
Loggerhead	91-99 Average	50%	31,972	127,888
Loggerhead	1999 Value	50%	18,747	74,988
Leatherback	91-99 Average	25%	325,208	1,300,832
Leatherback	1999 Value	25%	125,463	501,852
Leatherback	91-99 Average	50%	68,047	272,188
Leatherback	1999 Value	50%	26,254	105,016

Table 3 illustrates the strong effect that the different catch rates and bycatch reduction effectiveness can have on the required level of effort. For planning purposes, we are focusing on testing measures that would have a 25% effectiveness for loggerhead turtles. The associated level of fishing effort (up to 611,000 hooks) could be completed in a reasonable amount of time; about 51 fishing trips to the NED over 1-1/2 years. We are assuming that average trips are 15 overnight sets of 800 hooks. An estimated eight to nine individual vessels might volunteer to participate in the research, fishing an average of 6 trips each over 1-1/2 fishing seasons.

Because of the lower catch rates of leatherbacks, the required level of effort to test these measures on leatherbacks at the 25% effectiveness level may not be feasible. Of course, if any of the measures prove more effective for leatherbacks than a 25% reduction, then we may be able to detect that difference with these levels of effort.

The treatment sets will be 1) natural squid bait with no hooks under the float lines 2) blue-dyed squid bait with no hooks under the float lines, and 3) mackerel bait with no hooks under the float lines. On all of the treatment sets the hooks adjacent to float lines will be spaced 20 fathoms from the float lines and hooks not adjacent to float lines will be spaced 40 fathoms apart. The control sets will use natural squid bait with hooks deployed at 40-fathom intervals and with hooks directly under each float line.

The experimental design will be to rotate treatment and control sets on each of the participating vessels. The treatment and control sets will be made in random order until each of the three treatments and control have been made (4 sets). This procedure will be repeated during the course of the experiment. Other than the specified bait and gear configuration, the vessel captain will determine when and where sets are made according to his normal practice

Observers will collect a suite of data on forms generated by the SEFSC Pelagic Longline Observer Program including the Longline Gear Configuration Log, the Longline Haul Log, and the Individual Animal Log, and the Sea Turtle Life History Form (Appendix I). Observers will record the number of swordfish and turtles hooked on each bait type and the position of the hook relative to floats. Participating captains, crews, and observers will follow NOAA guidelines and permit requirements for handling marine turtles hooked or entangled on longline gear. Turtles hooked or entangled will be brought on board using dip nets if size permits and all gear removed following recommended procedures. For turtles that cannot be brought aboard, gear will be removed using line cutter and de-hooker prototypes being developed as part of the turtle mitigation research project. Prototype line cutters and de-hookers will be evaluated by crews and observers and information on performance provided to NMFS. All live turtles brought aboard will be tagged with standard flipper tags and released. Turtles that appear stressed will be maintained onboard and given the opportunity to revive before release. Up to 20 loggerhead turtles may be outfitted with conventional satellite tags to study the behavior and movements of pelagic stage turtles. An additional number of turtles (up to 75) may be outfitted with archival pop-up satellite tags (PSAT) for the purpose of evaluating their effectiveness for the study of turtle life history, and to investigate the effectiveness of the technique for collecting information on post hooking survival.

The estimates of catch rates per hook of control and treatment groups will be computed from the sample data. Using these estimates, a one-tailed hypothesis test will be conducted to test if the true catch rate for the treatment group is lower than that of the control group. Since the sample proportions are estimated from a large number of hooks, a test based on asymptotic normality to compare the two binomial proportions will be used here at a pre-specified level of significance. A confidence interval on the difference in the true proportions will also be computed. The Fisher's exact test and the likelihood ratio test will be performed as well and examined.

After the completion of the sampling in 2001, a preliminary analysis will be conducted. Depending on observed take rates and effectiveness of the tested treatments, the experimental testing may be terminated early or individual treatments may be eliminated (that is, if one or more treatments are determined to be clearly effective or ineffective based on the first year's data only).

PERSONNEL REQUIREMENTS FOR EXPERIMENTS IN THE WESTERN ATLANTIC

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Table 1. 2001 longline sea turtle mitigation research matrix

	MITIGATION									
	SST limit	Move from turtle interactions	Setting time	Line Cutters and de-hookers	Hook timers	Move hooks from floats	Bait studies	Fish hooks deeper	Stealth gear	Hook design
FISHERY DEPENDENT										
Grand Banks	X	X	X	X	X	X	X			X
Hawaii		X		X		X	X			
Mexico					X			X	X	X
Azores								X	X	X
FISHERY INDEPENDENT										
Captive Turtles							X		X	
Research Vessels							X		X	
Contract Vessels					X		X		X	X

Table 2. Estimated potential for mitigation measures proposed.

MITIGATION TECHNIQUE	CURRENT DATA AVAILABLE	ESTIMATED POTENTIAL EFFECTIVENESS
Use of line cutters and de-hooking devices		High potential, need data to quantify reduction in mortality
Upper limit on sea surface Temp (SST)	Hoey, NMFS contract report	Significant reduction for loggerheads and leatherbacks depending on upper limit. *
Moving away from turtle interaction area	Hoey, NMFS contract report	Unknown but could be significant for loggerheads *
Delay setting until after 9 p.m.	Hoey, NMFS contract report	Possible reduction for loggerheads and leatherbacks*
Use of blue dyed squid bait	Brill, Honolulu study	Laboratory studies indicate good potential
Use of hook timers		Data from hook timers can determine time of turtle hooking and target catch and provide data for more efficient mitigation measures
Move hooks away from floats	Kleiber and Boggs, 2000	Could be significant reduction *
Type of bait		Unknown
Fish hooks deeper		Unknown
Use of stealth gear		Unknown
Hook design (use circle hooks)	Bolton, LaGrange	Significant reduction in hooks ingested by turtles, 48% reduction in swordfish CPUE.
Turtle/swordfish behavioral information		Provide information necessary to design new mitigation measures
Deterrents/Attractors		High potential need basic research to provide direction
Hook guards		High potential need R&D effort
Stiffer monofilament		High potential for leatherback mitigation need R&D
Modify light sticks		Needs controlled experiments to determine potential

* Based on observer data

Appendix III. Sea Turtle Interactions During 2001 Experiments Under NMFS Permit #1324

SEA TURTLE INTERACTIONS DURING 2001
UNDER NMFS PERMIT #1324

Species	Total	Dead	Unknown
Caretta caretta	142	0	0
Dermochelys coriacea	77	0	1*

*The one leatherback of unknown condition was captured on October 17, 2001. The observer's comments were "The hook snapped out of the flesh of this turtle before anything other than basic observations could be made. Condition, interaction with gear, & final disposition of turtle are unknown. " During debriefing on November 14 the observer explained the event to Sheryan Epperly; her recorded comments are "Snap already had been passed to stern (didn't think anything was on gangion) & boat kept moving. [observer name] noticed tension building on line & a Dc flipper sfc. [ed] followed by body. Hook and all gear snapped out of turtle towards boat and crew ducked - got all gear back. Thus, turtle was hooked but not known where. Condition was totally unknown - either alive/injured or comatose (probably former)."

Evidently there was no evidence that there was anything on the hook as it as being hauled. It was not until after the snap was passed aft that the mounting tension on the line was noted. It is most likely that this turtle was not entangled or hooked until the gangion was at the boat; other observers had reported seeing turtles follow the bait as the line was hauled to the boat. We therefore believe that this turtle was alive at the time of release and was not a dead weight on the line.

Data for each of the turtles captured follows. The data are sorted by species and date.

Sea Turtle Interactions in NED 2001 Experiment

trip	month	day	latdeg	latmin	londeg	lonmin	spec#	condition	hook_removed	entang	line_left	SCL	hooksite	species
C02006	9	28	44	7	48	15	2	"alive,injured"	No	No	0		ingested	CC
C02006	9	28	43	59	48	23	3	"alive,injured"	No	No	0		ingested	CC
C02006	10	1	43	34	48	46	5	"alive,injured"	No	No	0		ingested	CC
C02006	10	1	43	37	48	43	6	"alive,injured"	No	No	0	45	ingested	CC
C02006	10	3	43	35.3	48	32	10	"alive,injured"	No	No	0	45	ingested	CC
C02007	11	5	42	23	55	1	3	"alive,injured"	Yes	No	0	55	beak/tongue/mouth	CC
C02007	11	5	42	21	55	1	4	"alive,injured"	No	No	0	55	beak/tongue/mouth	CC
J02010	9	7	43	0	48	50	1	"alive,injured"	No	No	0.5	65	ingested	CC
J02010	9	8	43	10	48	23	3	"alive,injured"	No	No	0.5	65	ingested	CC
J02010	9	8	43	9	48	34	4	"alive,injured"	No	No	0.5	65	beak/tongue/mouth	CC
J02010	9	11	43	15	48	24	7	"alive,injured"	No	No	0.5	55	ingested	CC
J02010	9	12	43	13	48	23	9	"alive,injured"	No	No	0.5	55	ingested	CC
J02010	9	12	43	8	48	35	10	"alive,injured"	No	No	0.5	65	ingested	CC
J02010	9	12	43	6	48	44	11	"alive,injured"	Yes	No	0	55	beak/tongue/mouth	CC
J02010	9	13	48	9	48	37	12	"alive,injured"	No	No	0.1	55	beak/tongue/mouth	CC
J02010	9	13	42	57	48	55	14	"alive,injured"	No	No	0.1	55	beak/tongue/mouth	CC
J02010	9	13	42	53	49	2	15	"alive,injured"	No	No	0.5	55	ingested	CC
J02010	9	15	42	57	49	13	16	"alive,injured"	No	No	0.1	65	beak/tongue/mouth	CC
J02010	9	15	42	49	49	20	17	"alive,injured"	No	No	0.1	65	beak/tongue/mouth	CC
J02010	9	15	42	50	49	23	18	"alive,injured"	Yes	No	0	55	beak/tongue/mouth	CC
J02010	9	16	43	13	48	44	19	"alive,injured"	No	No	0.5	65	ingested	CC
J02010	9	16	43	5	48	50	20	"alive,injured"	No	No	0.5	55	ingested	CC
J02010	9	16	43	20	48	35	21	"alive,injured"	No	No	0.1	65	beak/tongue/mouth	CC
J02010	9	18	43	44	48	45	24	"alive,injured"	No	No	0.5	55	ingested	CC
J02010	9	17	43	47	48	22	22	"alive,injured"	No	No	0.1	55	beak/tongue/mouth	CC
J02010	9	17	43	43	48	43	23	"alive,injured"	No	No	0.5	55	ingested	CC
J02010	9	18	43	41	48	45	25	"alive,injured"	Yes	No	0	45	beak/tongue/mouth	CC
R02001	9	26	43	53.1	48	34.7	1	"alive,injured"	No	No	0.5	65	beak/tongue/mouth	CC
R02001	9	26	43	52.9	48	34.3	2	"alive,injured"	No	Yes	0.5	55	beak/tongue/mouth	CC
R02001	9	26	43	50.1	48	36.8	3	"alive,injured"	No	No	0.5	45	beak/tongue/mouth	CC
R02001	9	26	43	54.9	48	31.3	4	"alive,injured"	No	No	0.5	55	beak/tongue/mouth	CC
R02001	9	29	43	45.4	48	45.2	6	"alive,injured"	No	No	0	55	beak/tongue/mouth	CC
R02001	10	2	43	45.7	48	40.8	8	"alive,injured"	Yes	No	0	55	beak/tongue/mouth	CC

R02001	10	5	43	51.9	48	8.3	10	"alive,injured"	No	No	0	55	beak/tongue/mouth	CC
R02001	10	6	49	23.8	48	6.1	11	"alive,injured"	No	No	0.5	65	ingested	CC
R02001	10	6	43	56.3	48	10	12	"alive,injured"	No	No	0.6	55	beak/tongue/mouth	CC
R02001	10	7	44	1.1	48	10	13	"alive,injured"	No	No	0	55	beak/tongue/mouth	CC

trip	month	day	latdeg	latmin	londeg	lonmin	spec#	condition	hook_removed	entang	line_left	SCL	hooksite	species
R02001	10	9	44	1	48	10.2	14	"alive,injured"	No	No	0.25	55	ingested	CC
R02001	10	9	44	4.7	48	17	15	"alive,injured"	No	No	0	55	beak/tongue/mouth	CC
R02002	11	1	42	17.2	51	19	1	"alive,injured"	No	No	0.5	55	ingested	CC
I02003	10	18	41	58.7	48	24.1	1	"alive,injured"	No	No	0	65	beak/tongue/mouth	CC
I02003	10	18	42	10.8	48	17	2	"alive,injured"	No	No	0	65	ingested	CC
I02003	10	18	42	18.2	48	16.3	3	"alive,injured"	Yes	No	0	65	beak/tongue/mouth	CC
I02003	10	19	42	3	48	18	4	"alive,injured"	No	No	0.1	55	ingested	CC
I02003	10	19	42	5.9	48	16.3	5	"alive,injured"	No	No	0.2	65	ingested	CC
I02003	10	19	42	14.7	48	17	6	"alive,injured"	No	No	0.1	65	ingested	CC
J02011	11	2	43	54	46	29	37	"alive,injured"	Yes	No	0	65	beak/tongue/mouth	CC
J02011	10	12	43	13	48	15	1	"alive,injured"	No	No	0.5	55	ingested	CC
J02011	10	14	46	13	45	22	2	"alive,injured"	Yes	No	0	65	beak/tongue/mouth	CC
J02011	10	15	46	10	44	34	3	"alive,injured"	No	No	0.1	55	beak/tongue/mouth	CC
J02011	11	1	43	24	47	18	6	"alive,injured"	No	No	0.5	65	ingested	CC
J02011	11	1	43	20	47	20	7	"alive,injured"	Yes	No	0	55	beak/tongue/mouth	CC
J02011	11	2	43	48	46	24	8	"alive,injured"	Yes	No	0	65	beak/tongue/mouth	CC
J02011	11	2	43	48	46	24	9	"alive,injured"	Yes	No	0	65	beak/tongue/mouth	CC
J02011	11	2	43	48	46	24	10	"alive,injured"	Yes	No	0	55	beak/tongue/mouth	CC
J02011	11	2	43	48	46	24	11	"alive,injured"	Yes	No	0	55	beak/tongue/mouth	CC
J02011	11	2	43	48	46	24	12	"alive,injured"	Yes	No	0	65	beak/tongue/mouth	CC
J02011	11	2	43	50	46	26	13	"alive,injured"	No	No	0.5	65	ingested	CC
J02011	11	2	43	50	46	26	14	"alive,injured"	No	No	0.5	65	ingested	CC
J02011	11	2	43	51	46	27	15	"alive,injured"	No	No	0.5	65	ingested	CC
J02011	11	2	43	53	46	27	16	"alive,injured"	No	No	0.5	65	ingested	CC
J02011	11	2	43	53	47	27	17	"alive,injured"	No	No	0.5	55	ingested	CC
J02011	11	2	43	53	46	27	19	"alive,injured"	Yes	No	0	55	beak/tongue/mouth	CC
J02011	11	2	43	53	46	28	20	"alive,injured"	No	No	0.5	55	ingested	CC
J02011	11	2	43	53	46	28	21	"alive,injured"	No	No	0.5	45	ingested	CC
J02011	11	2	43	53	47	22	22	"alive,injured"	No	No	0.5	55	ingested	CC
J02011	11	2	43	53	46	27	23	"alive,injured"	Yes	No	0	55	beak/tongue/mouth	CC

J02011	11	2	43	53	46	27	24	"alive,injured"	Yes	No	0	45	beak/tongue/mouth	CC
J02011	11	2	43	53	46	27	25	"alive,injured"	No	No	0.5	55	ingested	CC
J02011	11	2	43	53	46	27	26	"alive,injured"	Yes	No	0	55	beak/tongue/mouth	CC
J02011	11	2	43	48	47	28	27	"alive,injured"	No	No	0.5	65	ingested	CC
J02011	11	2	43	53	46	27	28	"alive,injured"	Yes	No	0	45	beak/tongue/mouth	CC
J02011	11	2	43	54	46	28	29	"alive,injured"	Yes	No	0	55	beak/tongue/mouth	CC
J02011	11	2	43	53	46	28	30	"alive,injured"	Yes	No	0	65	beak/tongue/mouth	CC
J02011	11	2	43	53	46	28	31	"alive,injured"	Yes	No	0	55	beak/tongue/mouth	CC

trip	month	day	latdeg	latmin	londeg	lonmin	spec#	condition	hook_removed	entang	line_left	SCL	hooksite	species
J02011	11	2	43	53	46	28	32	"alive,injured"	No	No	0.5	55	ingested	CC
J02011	11	2	43	54	46	28	33	"alive,injured"	No	No	0.5	65	ingested	CC
J02011	11	2	43	53	46	28	34	"alive,injured"	No	No	0.5	65	ingested	CC
J02011	11	2	43	53	46	28	35	"alive,injured"	Yes	No	0	65	beak/tongue/mouth	CC
W01021	9	12	43	48	48	27	1	"alive,injured"	No	No	0		ingested	CC
W01021	9	12	43	48	48	27	2	"alive,injured"	No	No	0	55	ingested	CC
W01021	9	15	43	15	48	41	4	"alive,injured"	No	No	0	55	ingested	CC
W01021	9	15	43	17	48	37	5	"alive,injured"	No	No	0	55	ingested	CC
W01022	10	3	43	5	48	39	18	"alive,injured"	Yes	No	0	45	"flipper,unknown"	CC
W01022	10	3	43	13	48	36	19	"alive,injured"	Yes	No	0	55	beak/tongue/mouth	CC
W01022	10	6	44	26	48	11	21	"alive,injured"	No	No	0.2	55	ingested	CC
W01022	10	7	44	32	48	6	22	"alive,injured"	Yes	No	0	55	beak/tongue/mouth	CC
W01022	10	8	44	37	47	58	24	"alive,injured"	No	No	0.2	55	ingested	CC
W01022	10	8	44	16	48	11	25	"alive,injured"	No	No	0.2	55	ingested	CC
W01022	10	10	44	18	48	19	26	"alive,injured"	Yes	No	0	65	"flipper,unknown"	CC
J02011	11	2	43	53	46	27	18	"alive,injured"	No	No	0.5	55	ingested	CC
W01022	10	2	43	21	48	48	3	"alive,injured"	Yes	No	0	55	beak/tongue/mouth	CC
W01022	10	2	43	22	48	48	4	"alive,injured"	Yes	No	0	55	beak/tongue/mouth	CC
W01022	10	2	43	27	48	46	5	"alive,injured"	Yes	No	0	65	beak/tongue/mouth	CC
W01022	10	3	42	55	48	32	6	"alive,injured"	No	No	0.1	55	ingested	CC
W01022	10	3	42	54	48	31	7	"alive,injured"	No	No	0.1	55	ingested	CC
W01022	10	3	42	55	48	27	8	"alive,injured"	No	No	0.1	45	ingested	CC
W01022	10	3	42	56	48	27	9	"alive,injured"	No	No	0.1	45	ingested	CC
W01022	10	3	42	56	48	27	10	"alive,injured"	No	No	0.1	55	ingested	CC
W01022	10	3	42	57	48	27	11	"alive,injured"	No	No	0.1	55	ingested	CC
W01022	10	3	42	58	48	28	12	"alive,injured"	No	No	0.1	55	ingested	CC

W01022	10	3	42	58	48	28	13	"alive,injured"	No	No	0.1	55	ingested	CC
W01022	10	3	42	59	48	29	14	"alive,injured"	Yes	No	0	55	beak/tongue/mouth	CC
W01022	10	3	42	59	48	29	15	"alive,injured"	No	No	0.1	55	ingested	CC
W01022	10	3	43	1	48	31	16	"alive,injured"	No	No	0.1	75	ingested	CC
W01022	10	3	43	1	48	32	17	"alive,injured"	No	No	0.1	55	ingested	CC
M01021	9	17	44	25.7	48	23.3	8	"alive,injured"	No	No	0.9	45	ingested	CC
M01021	9	18	44	22.3	48	31.2	9	"alive,injured"	No	No	0	55	ingested	CC
M01022	10	8	44	5.4	48	9.8	1	"alive,injured"	No	No	0	65	ingested	CC
M01022	10	8	44	4.3	48	10	2	"alive,injured"	No	No	0	55	ingested	CC
M01022	10	8	43	55	48	9.4	3	"alive,injured"	No	No	0	55	ingested	CC
M01022	10	8	43	44.2	47	56.1	4	"alive,injured"	Yes	No	0	55	beak/tongue/mouth	CC
M01022	10	9	44	9.3	48	9.8	5	"alive,injured"	N/A	Yes	0	55	not hooked	CC

trip	month	day	latdeg	latmin	londeg	lonmin	spec#	condition	hook_removed	entang	line_left	SCL	hooksite	species
M01022	10	9	44	0.9	48	8	6	"alive,injured"	No	No	0.4	55	ingested	CC
M01022	10	10	44	17.7	48	17.2	8	"alive,injured"	No	No	0.4	55	ingested	CC
M01022	10	12	44	20.3	48	5.3	9	"alive,injured"	No	No	0	55	ingested	CC
M01022	10	13	44	26.8	47	56	10	"alive,injured"	No	No	0.4	55	ingested	CC
M01022	10	18	44	51.8	46	29.8	11	"alive,injured"	No	No	0	55	ingested	CC
I02002	9	6	43	10.9	48	33.6	1	"alive,injured"	No	No	0.1	55	ingested	CC
I02002	9	6	43	10.9	48	33.6	2	"alive,injured"	Yes	No	0	55	front flipper/shoulder/armpit	CC
I02002	9	23	44	2.2	48	26.7	5	"alive,injured"	Yes	No	0	55	beak/tongue/mouth	CC
I02002	9	24	43	47.7	48	31.3	10	"alive,injured"	No	No	0	65	ingested	CC
I02002	9	24	43	43	48	36.1	11	"alive,injured"	No	No	0	55	ingested	CC
I02002	9	25	43	54.1	48	30	13	"alive,injured"	No	No	0	55	ingested	CC
I02002	9	25	43	47	48	36.4	15	"alive,injured"	No	No	0	55	ingested	CC
I02002	9	25	43	45.6	48	36.7	16	"alive,injured"	No	No	0	55	ingested	CC
I02002	9	25	43	44.5	48	39.1	17	"alive,injured"	No	No	0	55	ingested	CC
T01062	9	25	44	33.4	47	54.8	10	"alive,injured"	Yes	No	0	55	beak/tongue/mouth	CC
L02001	10	18	43	34.6	48	7.6	2	"alive,injured"	Yes	No	0	65	beak/tongue/mouth	CC
L02001	10	21	44	23.8	48	10.7	4	"alive,injured"	No	No	0	45	beak/tongue/mouth	CC
L02001	10	22	44	24.1	48	14.7	6	"alive,injured"	Yes	No	0	55	beak/tongue/mouth	CC
X01007	10	11	43	27.7	48	6.5	6	"alive,injured"	No	No	0	55	ingested	CC
X01007	10	17	48	8.8	47	12.2	8	"alive,injured"	Yes	No	0	55	beak/tongue/mouth	CC
X01007	10	17	48	7.6	47	11.7	9	"alive,injured"	No	No	0	65	ingested	CC
X01007	10	17	48	7.6	47	11.7	10	"alive,injured"	Yes	No	0	55	beak/tongue/mouth	CC

X01007	10	17	43	9.1	45	0	11	"alive,injured"	Yes	No	0	55	beak/tongue/mouth	CC
X01007	10	17	44	3	44	9.1	12	"alive,injured"	N/A	Yes	0	45	not hooked	CC
X01007	10	17	44	2.2	47	8.4	13	"alive,injured"	No	No	0	55	ingested	CC
X01007	10	17	44	0.4	47	6.3	14	"alive,injured"	No	No	0	55	ingested	CC
X01007	10	17	43	59	47	2.6	15	"alive,injured"	Yes	No	0	55	beak/tongue/mouth	CC
X01007	10	17	44	1.8	47	0.8	17	"alive,injured"	No	No	0.13	65	ingested	CC
X01007	10	17	44	8.4	47	1.2	19	"alive,injured"	No	No	0	65	ingested	CC
C02006	9	28	44	13	48	8	1	"alive,injured"	No	No	1		beak/head/neck	DC
C02006	9	30	43	32	48	50	4	"alive,injured"	No	Yes	2		front flipper/shoulder/armpit	DC
C02006	10	2	43	40.7	48	30.9	7	"alive,injured"	Yes	No	0		front flipper/shoulder/armpit	DC
C02006	10	2	43	45	48	17	8	"alive,injured"	No	No	2		front flipper/shoulder/armpit	DC
C02006	10	3	43	14.5	48	36.4	9	"alive,injured"	No	No	4		"unknown,external"	DC
C02007	10	25	43	7	54	11	1	"alive,injured"	No	No	0		front flipper/shoulder/armpit	DC
C02007	11	2	42	8	51	9	2	"alive,injured"	No	Yes	3		"unknown,external"	DC
J02010	9	8	43	16	49	12	2	"alive,injured"	No	No	3		front flipper/shoulder/armpit	DC
J02010	9	10	43	10	48	32	5	"alive,injured"	No	No	0		front flipper/shoulder/armpit	DC

trip	month	day	latdeg	latmin	londeg	lonmin	spec#	condition	hook_removed	entang	line_left	SCL	hooksite	species
J02010	9	10	43	6	48	37	6	"alive,injured"	No	No	1		carapace/plastron	DC
J02010	9	13	43	0	48	49	13	"alive,injured"	No	No	6		front flipper/shoulder/armpit	DC
J02010	9	22	44	39	47	30	26	"alive,uninjured"	N/A	Yes	0		not hooked	DC
J02010	9	24	44	44	46	58	27	"alive,injured"	No	No	3		front flipper/shoulder/armpit	DC
R02001	9	28	43	49.2	48	43.5	5	"alive,injured"	Yes	No	0		"flipper,unknown"	DC
R02001	10	1	43	57.2	48	20.4	7	"alive,injured"	Yes	No	0		front flipper/shoulder/armpit	DC
R02001	10	4	43	48.7	48	8.8	9	"alive,injured"	No	No	6		front flipper/shoulder/armpit	DC
R02001	10	10	43	56	48	19.1	16	"alive,injured"	Yes	Yes	15		front flipper/shoulder/armpit	DC
R02001	10	10	43	54.1	48	18.6	17	"alive,injured"	N/A	Yes	20		not hooked	DC
R02001	10	10	43	51.9	48	17.7	18	"alive,injured"	Yes	Yes	10		front flipper/shoulder/armpit	DC
R02002	11	4	42	1.4	51	14.9	2	"alive,injured"	No	No	4		front flipper/shoulder/armpit	DC
X01007	10	3	43	41.5	48	8.6	1	"alive,uninjured"	N/A	Yes	0		not hooked	DC
X01007	10	5	44	0.6	48	5.4	2	"alive,uninjured"	N/A	Yes	0		not hooked	DC
X01007	10	5	43	43.2	47	53.1	3	"alive,injured"	No	No	2		front flipper/shoulder/armpit	DC
X01007	10	9	43	36.3	48	9.1	4	"alive,injured"	No	No	2		front flipper/shoulder/armpit	DC
X01007	10	19	44	38.6	47	50	20	"alive,injured"	Yes	No	0		front flipper/shoulder/armpit	DC
X01007	10	19	44	27.8	48	11.1	21	"alive,injured"	Yes	No	0		front flipper/shoulder/armpit	DC
X01007	10	19	44	27.5	48	10.6	22	"alive,injured"	No	No	0.5		front flipper/shoulder/armpit	DC

I02003	10	22	42	58.4	51	32.8	7	"alive,injured"	No	No	1		front flipper/shoulder/armpit	DC
I02003	10	23	42	56.5	51	37.8	8	"alive,injured"	No	No	0.3		front flipper/shoulder/armpit	DC
I02003	10	24	42	58.8	51	51.4	9	"alive,injured"	No	No	0.5		front flipper/shoulder/armpit	DC
I02003	10	25	42	10.4	51	6.9	10	"alive,injured"	No	Yes	0.5		front flipper/shoulder/armpit	DC
I02003	10	27	43	12.4	53	42.8	11	"alive,injured"	No	Yes	0.5		front flipper/shoulder/armpit	DC
J02011	10	26	44	37	47	54	4	"alive,injured"	No	No	2		front flipper/shoulder/armpit	DC
J02011	10	27	44	35	47	45	5	"alive,injured"	No	No	25		front flipper/shoulder/armpit	DC
J02011	11	2	43	54	46	29	36	"alive,injured"	No	No	10		front flipper/shoulder/armpit	DC
X01006	9	5	44	13.5	48	8.3	1	"alive,injured"	Yes	Yes	0		front flipper/shoulder/armpit	DC
X01006	9	5	43	34	48	18.7	2	"alive,injured"	Yes	No	0		front flipper/shoulder/armpit	DC
W01021	9	15	43	0	49	4	3	"alive,injured"	No	No	0.5		front flipper/shoulder/armpit	DC
W01022	10	2	43	17	48	50	1	"alive,uninjured"	N/A	Yes	0		not hooked	DC
W01022	10	2	43	20	48	48	2	"alive,injured"	No	No	6		beak/tongue/mouth	DC
W01022	10	4	43	59	48	20	20	"alive,injured"	No	No	5		carapace/plastron	DC
W01022	10	7	44	12	48	11	23	"alive,uninjured"	N/A	Yes	0		not hooked	DC
W01022	10	12	44	36	47	51	27	"alive,injured"	No	No	10		"flipper,unknown"	DC
M01021	9	6	44	49	47	30.8	1	"alive,injured"	No	Yes	1		front flipper/shoulder/armpit	DC
M01021	9	9	44	43.4	48	0.1	2	"alive,uninjured"	N/A	Yes	0		not hooked	DC
M01021	9	9	44	42.4	48	0.7	3	"alive,injured"	No	No	0	45	front flipper/shoulder/armpit	DC
M01021	9	11	44	49.4	47	45.2	4	"alive,injured"	No	No	0		front flipper/shoulder/armpit	DC
trip	month	day	latdeg	latmin	londeg	lonmin	spec#	condition	hook_removed	entang	line_left	SCL	hooksite	species
M01021	9	13	44	29.1	48	12.1	5	"alive,injured"	Yes	No	0		front flipper/shoulder/armpit	DC
I02002	9	23	44	0.8	48	28.2	6	"alive,injured"	No	Yes	1		front flipper/shoulder/armpit	DC
M01021	9	16	44	29.9	48	0.9	6	"alive,uninjured"	N/A	Yes	0		not hooked	DC
M01021	9	16	44	27.4	48	6.1	7	"alive,injured"	No	No	0.4		front flipper/shoulder/armpit	DC
M01022	10	9	43	51.8	48	12.4	7	"alive,uninjured"	N/A	Yes	0		not hooked	DC
M01022	10	22	44	1.9	45	27.2	12	"alive,injured"	No	No	0		front flipper/shoulder/armpit	DC
I02002	9	10	44	19.1	48	22.1	3	"alive,uninjured"	N/A	Yes	0		not hooked	DC
I02002	9	22	44	10.3	48	18.2	4	"alive,injured"	No	No	3		front flipper/shoulder/armpit	DC
I02002	9	24	44	1.7	48	26.1	7	"alive,injured"	No	No	2		front flipper/shoulder/armpit	DC
I02002	9	24	44	0.2	48	26.6	8	"alive,injured"	N/A	Yes	5		not hooked	DC
I02002	9	24	43	58.4	48	27.1	9	"alive,uninjured"	N/A	Yes	0		not hooked	DC
I02002	9	25	44	3.9	48	28	12	"alive,injured"	No	Yes	3		front flipper/shoulder/armpit	DC
I02002	9	25	43	47.4	48	36.5	14	"alive,injured"	No	No	1		front flipper/shoulder/armpit	DC
T01062	9	5	44	42	48	2	1	"alive,injured"	No	No	0		front flipper/shoulder/armpit	DC

T01062	9	5	44	36	48	10	2	"alive,injured"	Yes	No	0	front flipper/shoulder/armpit	DC
T01062	9	6	44	50	47	34	3	"alive,injured"	Yes	No	0	front flipper/shoulder/armpit	DC
T01062	9	7	44	50	47	38	4	"alive,injured"	Yes	Yes	10	front flipper/shoulder/armpit	DC
T01062	9	11	44	41	47	58.9	5	"alive,injured"	Yes	No	0	front flipper/shoulder/armpit	DC
T01062	9	11	44	37	48	8.7	6	"alive,injured"	Yes	No	0	front flipper/shoulder/armpit	DC
T01062	9	22	44	38.2	47	8.2	7	"alive,injured"	Yes	Yes	0	front flipper/shoulder/armpit	DC
T01062	9	22	44	41.4	47	23.7	8	"alive,injured"	Yes	No	0	carapace/plastron	DC
T01062	9	25	44	34.5	47	52.4	9	"alive,injured"	Yes	No	0	front flipper/shoulder/armpit	DC
L02001	10	16	42	33	48	42.2	1	"alive,injured"	No	Yes	4.7	front flipper/shoulder/armpit	DC
L02001	10	20	44	14.1	48	13	3	"alive,uninjured"	N/A	Yes	0	not hooked	DC
L02001	10	21	44	30	48	15	5	"alive,injured"	Yes	No	0	front flipper/shoulder/armpit	DC
J02010	9	11	43	9	48	35	8	"alive,injured"	No	No	6	carapace/plastron	DC
X01007	10	11	43	42.8	48	0.9	5	"alive,injured"	Yes	No	0	front flipper/shoulder/armpit	DC
X01007	10	17	46	6.1	45	14.4	7	"alive,injured"	No	Yes	0.25	front flipper/shoulder/armpit	DC
X01007	10	17	43	59.6	47	2.1	16	"other,unknown"	Yes	No	0	unknown	DC
X01007	10	17	44	5.1	47	0.6	18	"alive,unknown"	No	Unk	9	unknown	DC

Appendix IV. Development of an Experimental Design and Research Plan to Estimate Post-Hooking Survival of Sea Turtles Captured in Pelagic Longline Fisheries.

DEVELOPMENT OF AN EXPERIMENTAL DESIGN AND RESEARCH PLAN TO ESTIMATE POST-HOOKING SURVIVAL OF SEA TURTLES CAPTURED IN PELAGIC LONGLINE FISHERIES

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BACKGROUND

Pelagic longline fishing is widespread throughout the world's oceans. It targets large pelagic species such as tunas, swordfish, and sharks, but the fishery also takes significant numbers of non-target species such as sea birds, sharks, and marine turtles. The impact of this fishery is believed to have a significant impact on the recovery of the marine turtles; all but one of the 7 species is listed as an endangered or threatened species. Leatherbacks of all life stages and young, oceanic stage loggerheads are the two species most often encountered in the U.S.-based fisheries. Leatherbacks generally become entangled in the gear whereas loggerheads usually attempt to ingest the bait and a significant proportion swallow the hook.[2] Recent management actions have strived to reduce the impact of the fishery on the stocks in both the Pacific and Atlantic Ocean basins, and prime fishing grounds have been closed to U.S. fishermen in an attempt to reduce the number of animals killed (Federal Register, 1999, 2000a, 200b, 2001a, 2001b, 2002).

Although the number of turtles captured by the fishery has been estimated for some fleets, the actual number of animals removed from the populations due to capture-related mortality is undetermined and management agencies' estimates are hotly contested by the industry. Most turtles are alive when brought onboard, but it is reasonable to assume that given the extent of their injuries, some die after being released and many more may be compromised for an extended period of time. Recently NMFS' Office of Science and Technology coordinated a review of existing post-hooking mortality data.[3] They pointed out that scientific data to answer the question of post-hooking mortality are inconclusive and that disparate opinions exist between

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[1]Curriculum vitaes of the principle investigators are attached.

[2]National Marine Fisheries Service, Southeast Fisheries Science Center. unpubl. data.

[3]Mortality of Sea Turtles in Pelagic Longline Fisheries - DECISION MEMORANDUM from William W. Fox, Jr., Donald R. Knowles, and Bruce C. Morehead to William T. Hogarth. February 16, 2001, 4 p. National Marine Fisheries Service, 1315 East-West Highway, Silver Spring, MD 20910.

scientists and managers. In reaching a consensus, they identified 4 categories of interaction; the associated mortalities, based on a precautionary approach, ranged from 0% to 100% (Table 1).

We propose to evaluate loggerhead sea turtle post-hooking mortality associated with the pelagic longline fishery in the North Atlantic. With these data, researchers can evaluate the impact of the pelagic longline fisheries on the turtle populations. We have designed an experiment to measure the mortality in 3 of the 4 categories identified in Table 1. The purpose of this document is to provide details on the experimental design, where available at this time, as well as the justification for each design element. Also, we detail the pilot study and review results to date. The term survival used throughout, usually refers to annual survival, unless noted otherwise. Also, the term control is used to describe Category 1, which actually is a treatment group, but one with expected minimal impact from the fishery interaction.

Table 1. Mortality associated with a sea turtle's interaction with a pelagic longline.

Category	Estimate of Post-Interaction Mortality	Description
1	0.00	No hooking, no injury, disentangled completely
2	0.27	Hooked externally or entangled, line left on animal (hook does not penetrate internal mouth structure e.g., lip hook).
3	0.42	Mouth hooked [penetrates] or ingested hook
4	1.00	Dead

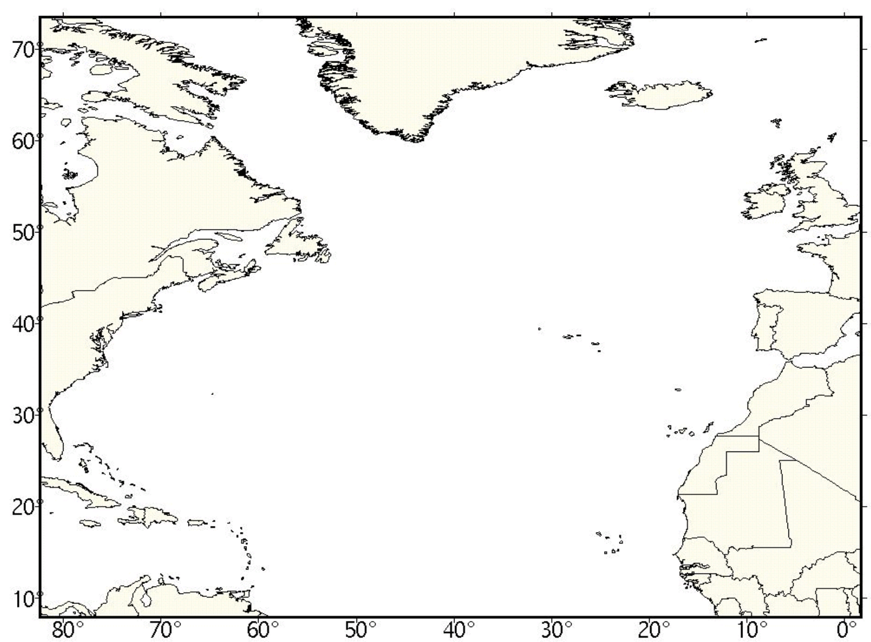

Figure 1. The North Atlantic Ocean

EXPERIMENTAL DESIGN

Certain design elements must be considered before one can evaluate whether a post-hooking survival experiment is feasible and will provide meaningful results. Important considerations are the duration of monitoring, sample size, and technology availability and limitations.

Duration of Monitoring

The experiment must be designed to measure the impact of the single interaction event, balancing duration to full mortality expression against natural mortality and other factors. There are two approaches to determine the post-hooking survival of animals interacting with the pelagic longline fishery. One method is to monitor impacted animals only for a short period during which it is assumed that the vast majority of associated mortality would be expressed. This would be the method of choice if the associated post-interaction mortality is likely to occur soon after the interaction and therefore natural mortality and other factors acting during the time lapse can be considered negligible. The other approach is to monitor the animals over a much longer period of time during which natural mortality and other factors may be acting. This method must be used when the vast majority of associated post-interaction mortality is not as likely to occur soon after the interaction. Without information on natural mortality and the other factors, however, estimates of post-hooking mortality would be biased high. Thus, one must also monitor a control group of animals to factor out the other sources of mortality acting on the treatment group.

There is general agreement that post-hooking mortality of sea turtles occurs over an extended period of time following the interaction.[3] While some mortality, including drowning, may be immediate, some mortality may be delayed. Harmful effects, including mortality, may result from tissue damage, infection, and digestive track blockage. Both the hooks and attached line are problematic and both can cause lesions that may become infected. The hook may puncture internal organs or vessels, but they also may become encapsulated[4] or be expelled (Aquilar et al., 1995). Line eventually may adhere to the lining of the digestive tract and cause death by torsion (involution)[5] or intussusception (telescoping effect)[6] of the gut (Richards, 2001[7]).

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[4]Jesus Tomas Aguirre. Personal communication May 18, 2001 to CTURTLE listserver.

[5]For an illustration of torsion see the following website: http://www.prescriptiondiet.com/NutritionandHealth/21.asp

[6]For an illustration of intussusception see the following website: http://www.prescriptiondiet.com/NutritionandHealth/25.asp

[7]Richards, M. 2001. The Dog Encyclopedia. TierCom, Inc. http://www.tiercom.com/

There are some data concerning the duration that the post-hooking mortality may be realized, but they are not conclusive. Of the 38 turtles held in captivity after capture by pelagic longlines in the western Mediterranean, 11 died in captivity, 6 expelled the hooks 53-285 days after capture, 15 were released 81-123 days after capture but prior to expelling the hooks, and 6 remained in captivity at the time of the report (Aguilar et al., 1995). Aquilar did indicate subsequently that most of the turtles that died in captivity succumbed within a few weeks.[8] A conventional satellite telemetry study in the Pacific found a high rate of failed transmissions - greater than expected based on tag failure alone - within 30 days (Parker et al., in press). After that period the duration of transmissions and distance traveled by lightly hooked and deeply hooked turtles were similar and all animals were reported to swim against a weak geostrophic flow. This is in contrast to conventional satellite telemetry results from the eastern Atlantic where telemetered turtles did not experience such a high proportion of failed transmissions during the first 30 days and the dive behavior of control turtles was significantly different from deeply hooked animals (Riewald et al., in press). Over a period of months the impacted animals made shallower and longer dives and did not use as full a range of the water column as control animals did. Also, the post-release movements of the two Atlantic groups differed significantly. Control animals swam actively and remained in the vicinity of the Mid-Atlantic ridge whereas tracking data of the impacted animals indicated the hooked turtles were moved passively by the currents eastward, away from the Mid-Atlantic ridge. It appears that primary mortality resulting from the impact may or may not occur soon after the event but it also appears that secondary mortality resulting from reduced fitness, as indicated by the Azores studies, may occur substantially later.

Thus, we propose to evaluate loggerhead sea turtle post-hooking mortality associated with the pelagic longline fishery over an extended period of time by comparing the survival of animals in a control group (Category 1 or dip netted from the surface) vs that of the two other groups (Categories 2 and 3). This method was chosen because data indicate that sea turtles may succumb to interaction-related mortality a significant amount of time after the event. Comparison of the cumulative number of deaths over time between the control and treatment groups will tell us when the majority of post-hooking mortality is occurring. This method has the added benefit of providing normal survival rates for oceanic stage loggerhead sea turtles which heretofore have not been measured. Past estimates of survival for this stage have resulted from population model inputs for the other stages which were used to solve for the survival rates for the missing stage.

Sample Size

The biggest determinants of sample size are (i) sources of error, (ii) variability, and (iii) precision required. Goodyear (in press) provides an excellent discussion on the factors affecting estimates of catch and release mortality using pop-off tag technology (see Technology section below) and recommends that under perfect conditions a minimum of about 100 tags should be

[8] Ricardo Aguilar, Greenpeace España. Personal communication to Eric Hawk, National Marine Fisheries Service, January 31, 2001.

released.   It must be recognized that this is a retrospective study: animals are not randomly assigned to a treatment group, but rather, will be sampled based on the treatment group that they belong to. Therefore it is very important to control for all other factors as much as possible.

It also is important to decide whether we are attempting to estimate the annual survival rates for each control and treatment group, or the effect size and its precision. The sample sizes needed for the former likely are much larger than for the latter. We believe that the data requirements are for the former, but we will be deliberating this question before designing the full study.

Sources of error

There are a number of sources of error, all of which tend to bias the mortality estimate upwards: tag failure, tagging induced mortality, natural mortality, and tag shedding. One complicating factor is if the treatment causes animals to be recaptured at a different rate than the controls. Natural mortality will be operative during the extended period that the telemetered turtles are at large, but can be factored into the estimates through our measurements of survival of the control group.

The longer a tag is at large the greater the chance of malfunction or shedding. Biases due to tag failure can be addressed by eliminating from the analysis any tags that fail to report, if we assume that tags applied to control animals are equally likely to fail to transmit as tags applied to treatment group animals. We can conceive of a couple of situations when this may not hold true. When a tag is at large for a long period of time (presumably more control animals than treatment animals will be at large for long time) there may be an increased chance of tag failure due to electronic failure or damage to the tag (such as the antenna) as well as decreased flotation due to biofouling. Proving the technology over an extended duration at large will be one of the goals of the pilot study.

We are assuming that we are not introducing any tag-induced mortality as we are using near-sterile techniques to attach the transmitter to the carapace and we are using biologically inert materials (nylon and stainless steel) for the attachment. Our control group of animals will be telemetered as well as the treatment groups of animals and they all will be treated the same while being tagged.   Thus, any impact of the tagging itself ought to impact all groups equally, including the control group. We cannot escape the fact, however, that the additional handling and the burden of carrying a transmitter may increase the risk of mortality to any turtle regardless of the condition of the turtle at the time of tagging.

Tag Shedding

Even though tags are programmed to pop-off on a certain date, they also can be programmed to begin transmitting earlier if certain premature release criteria are met (see Technology section below). A shed tag is an example of when we would want the data transmitted sooner than the programmed pop-off date. Also, at the death of the animal, we would want the tag to begin transmitting.

Tags that do not transmit until their programmed date will be assumed to have been attached to live animals at the time they popped-off, but the data transmitted will be used to confirm that hypothesis. Conversely, we cannot assume that all tags transmitting before their programmed date were released from animals that died. Tags may be released prematurely due to tag, tether, or animal failure. For example, the corrodible pin at the base of the tag to which the tether is attached may fail, releasing the tag. The attachment or the tether itself may fail, and lastly the behavior of the animal may be such that the premature release criteria are met when the animal is still alive. We will evaluate tag shedding and our ability to discern the status of the turtles involved during the pilot study.

It is essential to be able to evaluate the data of tags prematurely transmitting as one must determine the cause of the premature release. It is especially important that data on the normal diving behavior of a turtle are available to compare with data incoming from a transmitting tag. Those data exist for oceanic stage loggerheads in the eastern Atlantic and there is no reason to believe that similar-sized animals of the same species and life history stage located nearby on the Grand Banks would behave any differently. In 1998, 8 conventional satellite transmitters were deployed around the Azores, 3 on lightly hooked turtles and 5 on controls. In 2000, 18 were deployed, 8 on deeply hooked turtles and 10 on controls.

Variability, accuracy, and precision of estimates

Goodyear (in press) evaluated the outcomes of 1,000 simulated experiments for a combination of assumptions about the sources of error and the release mortality probability. Thes simulation essentially is the same as treating the observations as binomial variates for which the needed sample sizes can be estimated theoretically, but the results should be the same. He found that experiments releasing less than 100 tags would have a high probability of producing post-release mortality estimates that deviated by 5 percentage points or more and by 25% or more of the true value. In general, he found that the required sample size increased as the true post-release mortality decreased. When there are no complicating factors and the true post-release value is about 0.05, a thousand or more tags would be required to achieve a 90% probability that the estimate would be within 25% of the true value. If the true value is about 0.10, 250-500 tags would be required. More than 100 tags would be required if the true value is about 0.25, and about 50 tags would be required if the true value is about 0.50. An increase in precision would require an increase in sample size. These results are not directly applicable since only estimates of post-hooking mortality were being considered, not that of a control group in comparison to that of a treatment group. Similarly, though, sample size is a function of the absolute treatment mortality. If the variance is greater than expected for a binomial distribution, then an even larger sample size will be needed.

In order to evaluate the precision required for the loggerhead turtle post-hooking survival studies, we compared a range of normal survival rate estimates (e.g., expected survival rates for the control group of turtles) (Table 2) as determined in population modeling exercises (Epperly et al., 2001) to the range of expected survival rates of the treatment groups of turtles (Table 3). The range of normal survival rate estimates reported for the oceanic stage range from about 0.5 to 0.9. These are the average survival rates for the oceanic stage[9] and it is likely that because the loggerheads being impacted by the pelagic longline fishery are the largest animals of this stage (Bolten et al., 1994; Ferreira et al., 2001), their survival may be higher than the average for the stage (but necessarily less than 1.0). Survival estimates of the treatment groups will be compared to survival estimates for the control group (S) to determine the post-hooking mortality associated with that particular treatment.

Table 2. Estimates of annual survival for oceanic stage juvenile loggerhead sea turtles (Epperly et al., 2001). Models 1 and 2 are based on published growth rates and Models 3 and 4 are based on recently calculated growth rates which are considered more characteristic of the northern subpopulation. Stage durations are based on minimum size at stage (Models 1 and 3) and average size of transition to stage (Models 2 and 4). The population growth rates (8) represent 3 possibilities examined for the period prior to the implementation of turtle excluder devices in 1990.

Annual Survival Rates for Oceanic Juveniles				
8	Model 1	Model 2	Model 3	Model 4
0.95	0.744	0.910	0.510	0.585
0.97	0.803	0.900	0.565	0.657
1.00	0.894	(>1.00)	0.660	0.780

The annual survival rate of hooked animals can be estimated as a cumulative probability. The proportion of turtles that die in the year following a hooking event is equal to the proportion that survive the hooking event (1 - PHM) times the normal mortality rate (A) plus the proportion that die from the hooking event (post hooking mortality, PHM). Thus, the new survival rate expected for a treatment group is (1 - PHM) * S. The expected survival rates for the various scenarios of S and PHM combinations are given below (Table 3). We expect turtles in the control group to exhibit survival rates equal to S.

[9] Survival during the first year of life is incorporated into the fecundity term (Epperly et al., 2001)

Table 3. Expected survival rates of hooked turtles given S = 0.5-0.9 and (1 - Post Hooking Mortality) = 0.5-0.95.

	(1 - Post Hooking Mortality):					
S	0.5	0.6	0.7	0.8	0.9	0.95
0.5	0.25	0.3	0.35	0.4	0.45	0.475
0.6	0.3	0.36	0.42	0.48	0.54	0.57
0.7	0.35	0.42	0.49	0.56	0.63	0.665
0.8	0.4	0.48	0.56	0.64	0.72	0.76
0.9	0.45	0.54	0.63	0.72	0.81	0.855

We will require precision necessary to distinguish between these experimental groups and the control group. Those differences are illustrated below (Figure 2) and range from 0.025 (S=0.5 and PHM = 0.05) to 0.45 (S=0.9 and PHM=0.5). For the range of likely values of S (0.5-0.7) and PHM (0.20-0.50) the differences in expected survival rates of hooked turtles range from 0.1 to 0.35. As PHM decreases the requirements for precision to make accurate estimates increase.

There are number of statistical approaches that can be taken to estimate the necessary sample size and the estimates depend on how the data will be analyzed once they are collected. One method, described above evaluates the additive to probability of death and it may be a relatively poor model. Other models such as additive in the logit and additive hazzard may have more statistical power. It appears that the sample size must be relatively large, however, in any case. We must also plan for the effective sample size - the number of tag results remaining after censoring records, non-transmission, etc - and inflate our estimate of sample size so that we realize what actually is needed. After accounting for tag failures, shedding, etc., the number that must be released to actually realize the required effective sample size may be substantially larger than estimated by these models.

Based on the expected rates of post-hooking mortality we predict that we will need to release more than 100 tags per experimental group, in addition to 100+ tags on control animals in order to estimate the post-hooking survival rates with the needed precision across the range of values that we may encounter. Actual sample sizes will be determined once pilot study results are available. In the interim we will continue to evaluate the models for the statistical analyses.

Bycatch estimates, based on observer and logbook data from past years on the Grand Banks indicate turtles are abundant enough to acquire 100+ animals in the two treatment groups. Entangled or externally hooked animals that may serve as controls will not be brought onboard in sufficient numbers and we must determine other methods/fleets/areas to acquire them. Catch is a function of effort and current fishing by the U.S. fleet on the Grand Banks is restricted to vessels contracted for an experiment to evaluate measures to both reduce the rate of interactions and to reduce the mortality arising from the interactions. Thus, it is anticipated that the availability of turtles through the U.S. fleet will be diminished over historical levels. The consequence is that the experiment may take several years or that we may need to involve more than one area or fleet. It is preferable to involve more than one fleet in order not to introduce temporal or spatial variability. Each added category (time and area, as well as treatment), by reducing residuals' degrees of freedom, decreased our estimator precision.

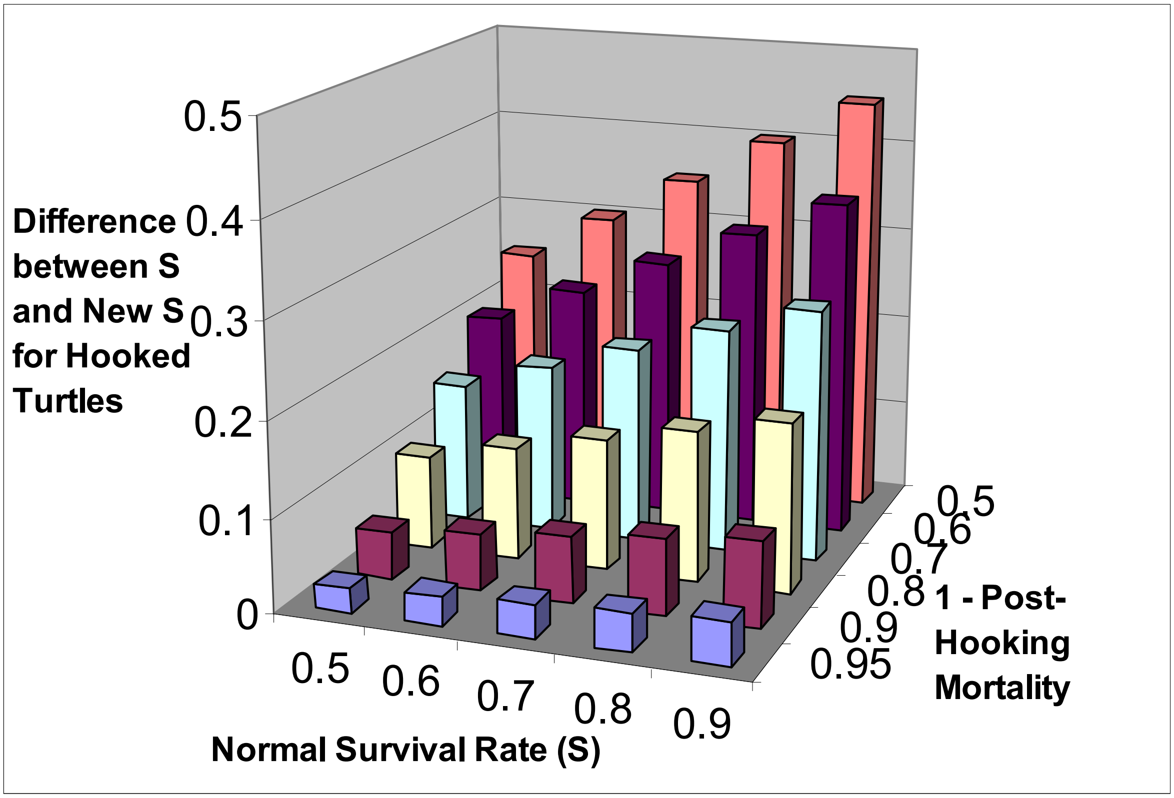

Figure 2. **The expected differences between the survival rates of control animals (S) and the survival rates of hooked animals**.

It may be necessary to deploy tags in more than one location (e.g., Grand Banks and Azores) in order to obtain all the animals needed, especially the control turtles and/or involve other fleets, such as the Canadian fleet fishing on the Grand Banks, but this is less than optimal However, since it is the effect of the entanglement and hooking that is being evaluated, as long as the treatment received (hooks and line removed, as possible) onboard the vessels is identical among the locations, the pooling of data from more than one location/fleet may not impact the post-hooking mortality estimates, unless the underlying normal survival rates differ, in which case the data must be examined separately. Ideally control animals should be obtained independent of the fishery, but animals taken by the fishery which are in category 1 may also serve as controls. Researchers in the Azores have demonstrated that they could dipnet large numbers of oceanic loggerheads from the surface (Bolten et al., 1993). We could selectively telemeter dip netted animals to mimic the size classes captured by the pelagic longline fishery (the fishery is selective for the large animals). We will investigate the feasibility of obtaining animals on the Grand Banks independent of the U.S. longline fishery experiments; if any animals are actually taken outside the experiment, they must be authorized by a Sec. 10 permit independent of the one issued for the experiments.

Technology

The only feasible method of conducting post-hooking mortality studies of a large number of animals in the open ocean over an extended period of time is a technology that would transmit data remotely to a central location. It is not feasible to track individual animals using sonic or radio tags for such an experiment.

Conventional satellite tags have been used for the purpose of determining post-hooking mortality with limited success[3]. The main drawback is that once transmission ceased, one could not determine whether the tag (or battery) failed, the attachment failed, or if the turtle died. Thus, results obtained from these tags are ambiguous about survival. Archival tags record detailed data about the animal, but the tag must be retrieved to acquire the data. Recently these two technologies have merged and studies have demonstrated its efficacy in survival studies (Block et al, 1998).

Pop-off Archival Transmitting (PAT) tags are attached externally to the animal and are released at pre-programmed dates using a corrosive linkage. Once released, they float to the surface and begin transmitting summarized data to the Argos satellite. These tags record and archive temperature and depth data and summarize it over specified periods of time to be transmitted later. Other data, such as light levels or angles of inclination may be recorded and transmitted, also. The detailed data are stored in non-volatile memory and can be retrieved if the tag is returned.

We investigated different sources of these tags and concluded that the PAT tag marketed by Wildlife Computers[10] best met the needs of this particular project. Most important in this decision were tag features that allowed the user to program many settings of the tag. For example, the onboard software is fully programmable and can be upgraded. These features provide for maximum information and safeguards so that tag failure would be minimized. The premature release criteria ensure that the tag begins transmitting as soon as the criteria are met and thus the tag does not float passively until its pop-off date. Also, a mechanical device is provided which severs the tether at slightly shallower depth than would crush the tag, ensuring that the tag is not dragged into the abyss. These features maximize the amount and quality of data received, with the transmitting of data immediately after premature release. Archived data are transmitted for the full duration of the remaining battery life rather than irrelevant data being collected between the time of premature release and the programmed pop-off date and competing with relevant data for transmission. Tag settings are discussed below.

Tags deployed on sea turtles must weigh less than 5% of the turtle's body weight; this generally is a requirement of the ESA permits which must be obtained. A 45 cm oceanic stage

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[10]Wildlife Computers, 16150 NE 85th St., Suite 226, Redmond, WA 98052

loggerhead weighs about 13-15 kg. The PAT tag weighs 0.080 kg and the RD-1500 weighs 0.010 kg, considerably less than 5% of the body weight.

Tag settings

The PAT tag is fully programmable and many setting choices can be selected by the user.

Frequency of data collection: By default data on temperature, depth, and light levels are collected and archived every minute, but the user can program a different collection frequency. We will make no changes to the default setting as the cost, in battery power, is negligible to store the data. Collecting such detailed data is particularly beneficial if the tag is recovered later.

Histogram Limits and Summarization Intervals: Time-at-depth and Time-at-temperature data are summarized and the histograms are later transmitted. The PAT tag allows 12 discrete depth and 12 discrete temperature intervals to be specified. Temperature will be divided into 2 deg. C intervals over the range likely to be encountered on the fishing grounds (Table 4). We will create our depth intervals to mirror the settings of conventional satellite tags deployed on oceanic stage loggerheads in the eastern Atlantic (Riewald et al., in press). The conventional tags allow the user to define 14 rather than 12 bins. Therefore we combined depth bins based on results of the Azores study (Table 4).

Table 4. Programmed upper limits of depth and temperature bins of the PAT tags for the study of post-hooking mortality of loggerhead sea turtles.

Bin #	Depth (meters)	Temp (°C)
1	-1	10
2	1	12
3	3	14
4	5	16
5	25	18
6	35	20
7	50	22
8	60	24
9	75	26
10	100	28
11	125	30
12	1000	60

The number of summary histograms and depth-temperature profiles (PDT) stored daily can be specified. Conventional tags used in the Azores study summarized data over every 6 hr period, for a total of 4 histogram sets per day. Riewald et al. (in press) found a diurnal dive behavior and it would be ideal to program PAT data to be as comparable as possible. However, the greater the number of daily summaries, the greater the number of data records to be transmitted. As the number of summary records increases, the probability of receiving any one of them decreases. It is very important that we receive the greatest proportion of data records in order to determine the status of the turtle at the time of tag release. We will evaluate this setting in conjunction with transmission priorities (see below) during the pilot study.

Transmission priorities: Transmission priorities can be set for each type of data to none (off), low, medium, or high. This affects the relative frequency of transmission of the data. Priorities will be programmed to optimize the number of uncorrupted data records received concerning the behavior of the turtle. Transmission of histograms (time-at-depth and time-at-temperature data) will be set to high. Transmission of location and PDT data will be set to low or turned off since these are less important to a survival study. Transmission priority settings will be evaluated in the pilot study.

Premature Release Criteria: It is important to know if the tag was shed or if the animal died and floated to the surface or sank to the ocean floor. The premature release criteria feature can be disabled to ensure that the tag collects data for the entire duration until the programmed pop-off date. Enabling a premature release function is desirable, though, because we do not want to continue to collect data when the tag may no longer be on the turtle as this decreases the probability of receiving data streams collected when the tag was still attached to the turtle (see Histogram Limits and Summarization Intervals and Transmission Priorities sections above). Also, we would want to minimize the possibility of tag failure if that increases with time at large.

The criteria for premature release will be set conservatively to minimize the possibility of a tag being released from a live turtle, i.e. an indication of animal failure. Results from the Azores study showed that one hooked turtle was compromised for many months, varying its depth little (B. Riewald, pers. comm.[11]). It appeared that the animal eventually began to recover as evidenced by a wider range of dive depths with time. The number of hours permissible at a constant depth (24-96 hr), the amount of variability allowed in that depth (1-15 m), and the number of outliers to be allowed (0-60) all can be selected. Also, the user can set the depth that defines when the premature release detection program is started (5-50 m). These settings will be evaluated in the pilot study.

If a turtle died and sank to depths >2000 m, the tag would be crushed due to the increase in pressure at depth. The tags are shipped with a RD-1500 pressure release device that, if used, will sever the tether at approximately 1500 m. Once released from the turtle, the positively buoyant tag would float to the surface. If the premature release criteria are enabled, the tag eventually would recognize that it was at a constant depth (0 m) and begin transmitting. The turtle/tag's plummet to depth would be captured in the summary data transmitted. All tethers used in this project will have the RD-1500 device.

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[11]Brian Riewald personal communication to S.P. Epperly. August, 17, 2001.

Tag Time and Date: The PAT tag's internal clock time and date are set to Greenwich Mean Time (GMT). This is critical for calculating accurate locations. The offset of GMT can account for local time difference.

Pop-Off Date: The year, month, day, and hour of pop-off are programmed for every tag. There are several considerations bearing on the programming of pop-off date: (i) the duration to fully express the associated post-interaction mortality, (ii) the probability of receiving enough data transmissions to properly interpret the results, and (iii) whether the normal mortality may have a seasonal component.

The design of the tag is such that a popped-off tag will transmit continuously until the battery power is exhausted. If the antenna is under water, the transmission will fail to reach the Argos satellite. Rough seas likely will keep the antenna awash and we would expect to receive fewer data messages during such times. Because it is essential to maximize the returned data messages in order to interpret the results, we therefore do not want to program the tags to pop-off during times we anticipate the seas to be exceptionally rough (i.e., winter in the North Atlantic). Thus, we do not plan to program the pop-off date to occur during November-May.

Ultimately, weather dictates when fishing is possible and generally pelagic longline fishing on the Grand Banks by the U.S. fleet is seasonal, as it is for the Azores fleet fishing in the eastern Atlantic. Also, fishing by U.S. vessels on the Grand Banks is prohibited except for those vessels contracted by NMFS to fish under a rigid experimental design under an ESA Section 10 permit. Contracting constraints are such that it is unlikely that U.S. vessels are likely to fish on the Grand Banks prior to July 1 and it is unlikely that the contract for the Azores experiments can be in place any sooner than July 1 of each year either. Thus, we do not anticipate being able to deploy any tags prior to July 1.

Given the constraints of winter weather (beginning Nov. 1) and the earliest date of deployment (Jul. 1), the maximum duration we could monitor an animal during a single season is 4 months. This may or may not be sufficient for animals tagged on July 1, but likely is not adequate for monitoring animals tagged thereafter. Thus, we do not plan to program the tags to pop-off until the next season of good weather. Also, because there may be a seasonal component to mortality that is unrelated to the hooking event being measured, we plan to program the tags to accumulate data for about 1 year after release. Furthermore, scientists tend to monitor long-lived vertebrates in annual intervals. The extended duration of monitoring is a major difficulty but it is necessary to evaluate the effect of category 2 or 3 on post-hooking survival.

Operation: After programming the settings, there are a number of operation options available. The tag can be deployed immediately, deployment can be delayed, or operation can be suspended. Once a tag is deployed (e.g., activated) it begins collecting data. All our tags will be programmed and set to delayed deployment mode. Once an observer makes a decision to release a tag, they can deploy it at sea using a magnet to activate tag operation.

Attachment and the Tether

One of the most important components of the system is the tether and how it is attached to the animal. Our requirements were a method that (i) did not require a sterile environment and that would not compromise the turtle, (ii) results in an attachment and tether that would maintain its integrity for an extended duration, (iii) requires a relatively small amount of time to perform, and (iv) observers could be trained easily in attachment techniques. The first option we considered was to model our attachment and tether after that being used in the Hawaii-based studies of marine turtle post-hooking mortality (Swimmer et al., 2002[12]). They use a stout cylinder of syntactic foam (AM-40B) about 4" in diameter x 1" thick to create a base. A monofilament line is threaded, through the foam base and a stainless fender washer (1 ½" OD), and looped back through the center and crimped. The base is affixed to the carapace with a fast-curing epoxy paste (MarineFIX© FAST). We decided against using this method for several reasons: (i) The base is another surface for biofouling and if it separated from the carapace may be negatively buoyant and prevent the tag from transmitting; the base along with the attached marine epoxy resin was barely positively buoyant, (ii) The curing of the epoxy resin is exothermic and creates a significant amount of heat (125° F) that could be damaging to the turtle's carapace scutes, the underlying dermis and bone, as well as to the posterior lobe of the lung (Swimmer et al. 2002 noted no sign of underlying damage, however), (iii) the bond did not appear suitable for a long term deployment as it easily could be dislodged; 3 of 5 attachments tested on green turtles in captivity in Hawaii failed before 10 months. We also considered affixing the same foam base with a silicone elastomer and fiberglass cloth strips and resin per the methodology of conventional satellite tags, but determined that if the fiberglass separated from the carapace, the combined weight of the elastomer and fiberglass cloth and resin would result in a negatively buoyant base that would prevent the tag from transmitting successfully.

We then considered attaching the tether directly to the carapace. We briefly considered bone screws but after discussing this with Dr. Molly Lutcavage[13] and Dr. Anders Rhodin[14], determined that we could not maintain the necessary sterile field aboard the commercial vessels nor could we train the fisheries observers to surgically implant the screws. Dr. Rhodin suggested that through bolting should be our first choice. We then designed an attachment that involved drilling a pair of holes through the postcentral scutes and their fused peripheral bones (Figure 3). The postcentral scutes were selected because: (i) they are in a hydrodynamically slow flow region; (ii) they are supported by a pair of fused peripheral bones and provide a strong,

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[12]Swimmer, Y, R. Brill, and M. Musyl. 2002. Quantifying sea turtle mortality with PSATs. Pelagic Fisheries Research Program Newsletter 7(2):1-5. University of Hawai'i, Honolulu. http://www.soest.hawaii.edu/PFRP/pub_list_newsletter.html

[13]Molly Lutcavage, New England Aquarium. Personal Communication to S.P. Epperly, National Marine Fisheries Service, July 2001.

[14]Anders Rhodin, Chelonian Research Foundation, Personal Communication to S.P. Epperly, National Marine Fisheries Service, August 17, 2001.

accessible attachment site, and (iii) the tag and tether will be out of the way of the flippers and the turtle's visual field. A pair of holes is used rather than a single hole to balance the drag and to increase the chance of maintaining the integrity of the attachment by doubling the number of attachment points. Holes are drilled proximally on the postcentral scutes to prevent the attachment from pulling out, which would be more likely if the holes were drilled distally in the scutes through only the keratin. A stainless steel line eyestrap (9/16") is attached with 2 bolts (stainless or nylon, #10-24 x 1" - 2"), a washer (stainless or nylon), and a stainless lock nut (#10) with a nylon insert. Nylon is preferred (but not available in lengths > 1 ½ ") over stainless because it is expected to deteriorate more quickly than stainless (nylon polymer 66 resin is biologically inert and after about 2 years exposure to UV radiation will lose about 60% of its initial physical properties[15]; stainless will eventually corrode away and is used routinely in arthroscopic surgery and implants).

The tether should be long enough to allow the tag to follow behind (and somewhat slightly above) the posterior-most part of the carapace. However, the tether should be short enough so that the tether cannot wrap around the hind limb or allow the tag to bump the hind limbs. Using this set of criteria for tether length also allows the tag to reside within the wake of the turtle, effectively minimizing or eliminating any measurable hydrodynamic effects on locomotion. The tether we designed is 10 cm long and is optimal to float the tag in the carapace's turbulence field, but not too long to be caught by the rear flippers of the 40-60 cm SCL oceanic stage turtles. One end of the monofilament (280# test fluorocarbon, 0.0.071 in. diameter) is looped around the corrodible pin in the tag and crimped using stainless crimps (oval, for 1/16" wire rope). The other end is looped around a small stainless line thimble (2 mm) and crimped to protect the monofilament. The stainless thimble is attached to the eyestrap. The RD-1500 device is centered on the tether and adhesive-lined heat shrink tubing is applied over the monofilament (1/4") and the crimps (3/16") to either side to reduce the monofilament's exposure to U/V and to prevent abrasion of the line. The corrodible pin, which will break at 50 pounds of static weight (Wildlife Computers[16]), is the weak link of the system.

Throughout the attachment process, all attempts are being made to maintain as sterile a working environment as possible. The posterior carapace of the animal is being scrubbed several times with betadine and sterile gauze pads, and the area is numbed with ice. Holes are drilled using a 3/16" titanium (biologically inert) bit which, along with the stainless hardware, is soaked in betadine for at least 15 minutes before being used. Nylon bolts, which would be degraded by the iodine present in betadine, are swabbed with alcohol before being used. Clotisol, a clotting agent, is used to stem any bleeding resulting from the drilling and betadine is dripped into the holes as a disinfectant prior to threading the bolts through the scutes.

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[15]Dupont Engineering and Polymers Technical Group (Nancy). Personal Communication to S.P. Epperly, National Marine Fisheries Service, August 2001.

[16]Ann Rupley, Wildlife Computers. Personal Communication to S.P. Epperly, National Marine Fisheries Service, August 8, 2001.

Figure 3. **PAT tag attachment and tether.**

PILOT STUDY

A pilot study was designed to prove the validity of the technology for addressing post-release survival questions concerning juvenile loggerhead sea turtles in the oceanic environment. The objective is to evaluate tag performance as well as sources of error and to determine sample size. We need to evaluate the feasibility of the extended duration of monitoring: Can we maintain an attachment for one year? Will the tag still be positively buoyant at the end of one year? Will we receive enough uncorrupted data to determine if the turtle was alive or dead at the time of tag release? Lastly, we need to evaluate the multitude of programmable settings and optimize them for the study.

<u>2001</u>

We deployed 23 PAT tags for the pilot study in fall 2001 on the Grand Banks and in the vicinity of the Azores in the North Atlantic. The tags were programmed to pop-off during July-August 2002. Of the 7 released in the eastern Atlantic during September, 4 were set adrift without being attached to turtles to simulate a severely impacted turtle floating at the surface or to simulate a tag floating on the surface free of a turtle. Two tags were deployed on turtles that had been hooked in the beak, but the hooks were not penetrating into the underlying tissue. One was deployed on an animal that had ingested the hook, but nearly all line had been removed. Of the 16 deployed on the Grand Banks during September-October, 2 were on turtles that had only been entangled in line, not hooked, 2 had been hooked in the flipper, 3 were on turtles that had been hooked in the mouth, but the hook was not deeply embedded (2 fell out while the turtle was on deck; the other hook was only lightly embedded in the beak), and 9 were released on animals that had swallowed the hooks, but nearly all line had been removed. Because the beak/mouth-hooked turtles were so lightly hooked, we considered these, as well as the externally hooked or entangled turtles, as controls for the purpose of the pilot study.

The premature release criteria were enabled on all tags released on the Grand Banks, but were disabled on the tags released in the Azores. This feature was enabled on the Grand Banks releases to evaluate the premature release criteria and tag performance, especially for those that may pop-off during the winter. We also hoped to gain some preliminary data from these tags. The criteria of the Grand Banks releases were set such that if the tag was at a constant depth, ±2 m, for 96 hours with no outliers, the release sequence would be initiated and the tag would begin transmitting. This feature was disabled on the Azores releases to determine whether biofouling of the tag after 1 year at large was an issue (we will assume that if the tag transmits it is not an issue) and to evaluate tag performance (the proportion of records transmitted that are received after about 1 yr at large).

Transmission priorities were set as follows: histograms - high, PDT tables - low, and location data - low. The summarization interval was set to 12 hours to yield two sets of histograms per day. This is less than the 4 which were provided daily from conventional satellite tags used in the eastern Atlantic but it was necessary to reduce the summarization interval to ensure that most histograms would be received. With time at large of 250 days, we expected to receive 70% or more of the histograms uncorrupted (60% for 350 days at large)[17]; the proportion expected is higher for shorter deployment durations (Figure 4). All other program settings were the same as described above and were the same between the 2 study sites, except for the time offset UTM (time zones differed between the Azores and the Grand Banks).

To date eight of these tags have transmitted data; all had met the premature release criteria which triggered release. Five tags had been deployed on control turtles and 3 had been deployed on turtles that had swallowed the hook (Table 5). The 8 were deployed by 5 different observers. The minimum time at large was 106 days. Data from 7 tags (insufficient data were provided by the 8th) indicate that the perceived constant depth that initiated the premature release sequence was 0 m, the surface, and that none had dives below 600 m, which would have indicated the turtle had died and was sinking into the abyss. Data analyzed for 2 of the tags on control turtles, the first two to transmit, indicate that the turtles were behaving normally up to the time that the premature release sequence was initiated. There was no indication that either of the 2 tagged turtles were dead at the time of tag release, but death remains a possibility. If the

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[17]Expected performance is based on an average of 10,000 transmissions over the life of the battery with10% of those transmissions received uncorrupted by the Argos satellite (Roger Hill and Ann Rupley, Wildlife Computers. Personal communication to S.P. Epperly, National Marine Fisheries Service, August 15, 2001).

animals were preyed upon the tag may have been separated from the animal or perhaps the tag itself was a target of a predator. It is possible that either tag, tether, or animal failure occurred.

Table 5. PAT tags released in NED 2001 experiment that were transmitting before June 1, 2002.

PTT (PAT ID)	Release			Pop-Up Date
	Date	Trip	Condition	
15131 (P01-0018)	Oct. 18, 2001	I02003	control: hook fell out of beak on deck	Apr. 25, 2002
15784 (P01-0022)	Oct. 6, 2001	W01022	ingested: swallowed hook; lodged in throat	Apr. 3, 2002
15788 (P01-0026)	Oct. 19, 2001	I02003	ingested: deeply hooked in throat	May 28, 2002
15803 (P01-0031)	Oct. 17, 2001	X01007	control: entangled in left rear flipper; not hooked	Jan. 21, 2002
16299 (P01-0038)	Sep. 25, 2001	T010062	control: lightly beak hooked; hook removed easily	Mar. 8, 2003
16385 (P01-0039)	Oct. 12, 2001	J02011	ingested: swallowed the bait	Apr. 1, 2002
16597 (P01-0052)	Sep. 12, 2001	J02010	control: hook fell out of beak on deck	Apr. 5, 2002
17148 (P01-0044)	Sep. 6, 2001	I02002	control: hooked in left front flipper	Jan. 25, 2002

Another serious concern is the performance of the tags, measured as the proportion of data collected and transmitted that is received uncorrupted. Performance data for two were analyzed and indicated a much poorer performance than anticipated given the number of days at large, the number of summary histograms created daily, and the programmed transmission priorities. We expected to receive 95% of the histograms from the tag at large for 106 days but received 60-65%; for the tag at large for 142 days we expected to receive 89% but received 20-25%. The tags did transmit the amount of data expected (the number of records transmitted is a function of battery power and both are part of a status record transmitted regularly), but the messages were not received by the satellite or parts of the messages were corrupted. This could be explained by the rough seas present during the winter months when the antennas may have been awash and thus validates our concerns about winter-time releases. Although not yet analyzed, performance of the remaining 6 tags does not look good, either. Failure to receive the data compromises our ability to determine whether the animal was alive or dead at the time of tag release.

These preliminary results are reason for concern and warrant us proceeding with caution until all the pilot study results are returned and analyzed. We must evaluate all possible causes of system failure. We have discussed these results with Wildlife Computers and they already have increased the strength of the corrodible pin (from 50# to 90# static weight breaking strength) and are providing a plastic line thimble/bobbin to decrease any chafing of the monofilament tether around the pin. Since the pin is our weak link of the attachment system, we may or may not want to use the stronger pin - it is our option, but we must not compromise a turtle that could become entangled by the tag and needs to be able to break free. Also, they have changed the color of the float; previously it was white and now it will be gray, similar in color to the body of the tag and thus will appear less like a squid, a common prey item of the oceanic environment. Wildlife Computers may also be willing to machine the floats out of a less dense material, matching it with a compatible RD device (a less dense float would crush at a shallower depth). This would increase the buoyancy of the tag to counteract some possible biofouling and would float the tag slightly higher on the surface to facilitate transmissions. Also, Wildlife Computers is committed to making some software changes to allow a longer period than 96 hours for the premature release sequence evaluation; this likely would address animal failure if it is an issue. In the longer term, they are considering modifying the software so that the tag would not transmit continuously, but only during broad windows when the Argos satellite is overhead and the transmission is likely to be received. This would greatly increase the number of transmission received and increase our ability to interpret the incoming data. Software enhancements can be uploaded onto the remaining 9 tags in hand slated for 2002 deployment.

We are examining our tether closely for any sources of weakness: overtightened crimps, scarring by too much movement of the RD-1500 device, etc. and will make every improvement possible. We are confident in our method of attachment of the tether to the carapace, but we plan to test it this summer on captive animals held at the Galveston Lab.

<u>2002</u>

At this time we plan on releasing all remaining tags in hand (up to 9). To reduce the possibility of tag shedding we will use modified tethers. We have identified a 400 lb test line with the same diameter (0.18 cm) as the 280 lb test that we were using and will use the stronger filament for the tethers. Since movement of the RD-1500 could scar the monofilament and weaken it, we will explore methods to further isolate the motion of the RD-1500. One suggestion (Wildlife Computers[18]) has been to fill the void in the bottom of the device, through which the monofilament is threaded, with a bead of silicone caulk. We plan to remove any burrs in the PAT tag housing around the corrodible pin and we will add the line bobbin to the pin. We will upgrade onboard software as available. We will change but three settings. In order

[18]Roger Hill, Wildlife Computers. Personal communication to S.P. Epperly, National Marine Fisheries Service, April 8, 2002.

to decrease the probability of animal failure, premature release criteria will be modified such that the variance about the constant depth will be ±1 m, the minimum setting, rather than ±2 m and the amount of time over which a constant depth must be maintained will be doubled from 96 hr to 192 hr. In order to decrease the number of records to be transmitted and thus increase the probability of receiving those that are transmitted, the summarization interval will be 24 hr rather than 12 hours, providing a single set of histograms per day. Lastly, the priority of transmissions will be changed to eliminate the transmission of location data. These are not critical to the question of post-hooking survival and can be sacrificed in order to increase the probability of receiving the histogram records which are essential to the question. With these settings we expect to receive 90% of the histograms from an animal at large for 350 days (Figure 5). The Argos satellite provides location estimates for the transmitting tags and, with that and the release location information, we still can determine a straight-line distance between the release and pop-off locations.

The tags will be deployed on control turtles: those that have been entangled or hooked externally or dip netted from the surface. The tags will be programmed to pop-off early next summer (May 15-June 1), in time for us to use the information to program tags to be deployed in 2003. Lastly we plan to use this opportunity to investigate means to acquire control turtles without setting longlines to catch them and to investigate expansion of the project to include other fleets (e.g., Canadian and Azores).

During 2002 we also will acquire and analyze data transmitted from tags deployed in 2001. We will determine the feasibility of the extended duration of monitoring and the extent of tag shedding due to tag, tether, or animal failure. Assuming that feasibility is demonstrated, we will design the full experiment and begin deploying tags in 2003.

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The research in the Azores was conducted in collaboration with the Department of Oceanography, University of the Azores, Horta, through a Cooperative Agreement with the Archie Carr Center for Sea Turtle Research at the University of Florida.

We began this project with 4 co-PI's but we are now 3. We lost our colleague Brian Riewald in an accident during fall 2001. His contributions to the start-up of this project were enormous.

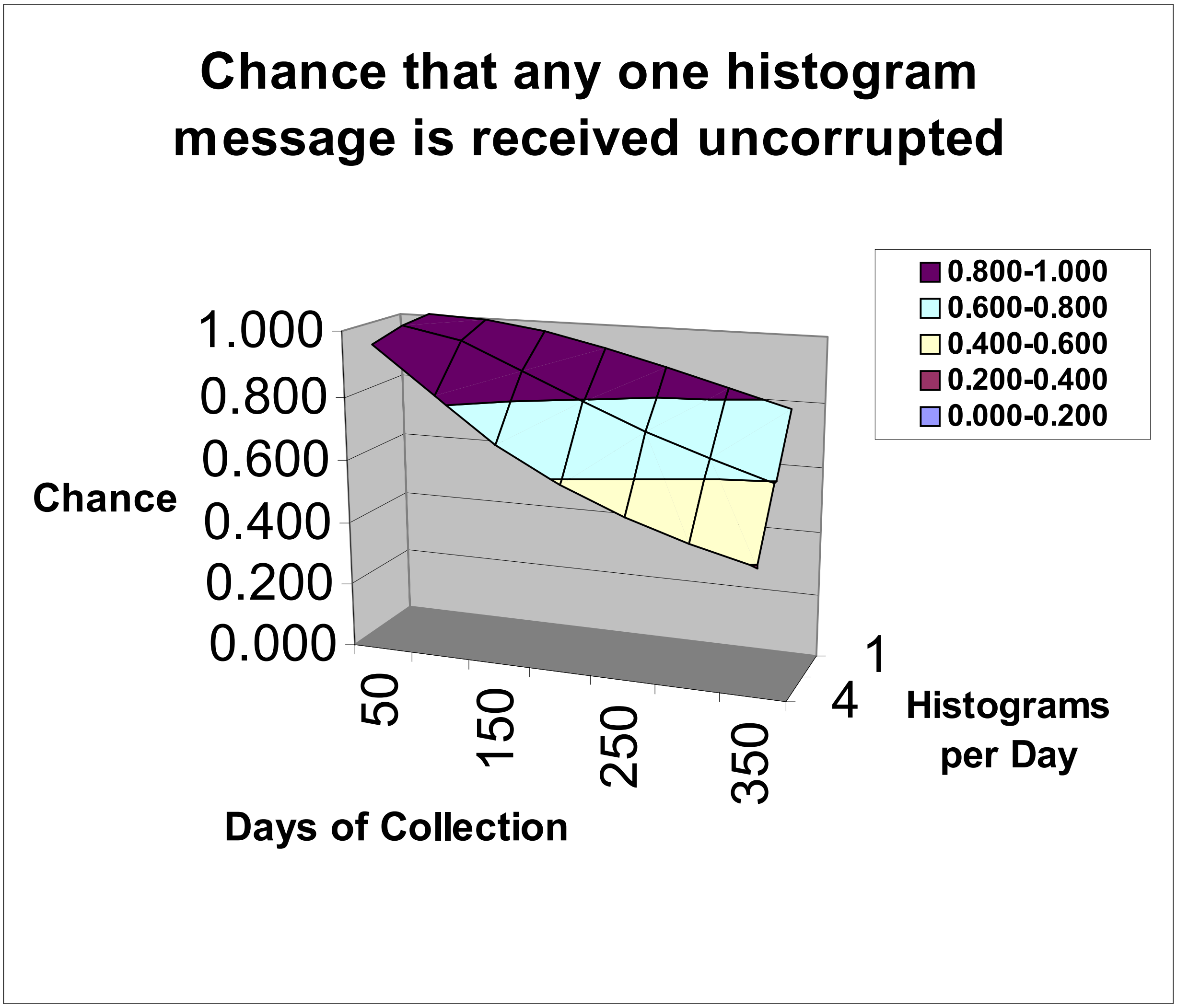

Figure 4. **Expected probability of a PAT tag histogram message being received uncorrupted as a function of duration and summarization interval when transmission priorities are: histograms-high, PDT tables-low, and location data-low.**

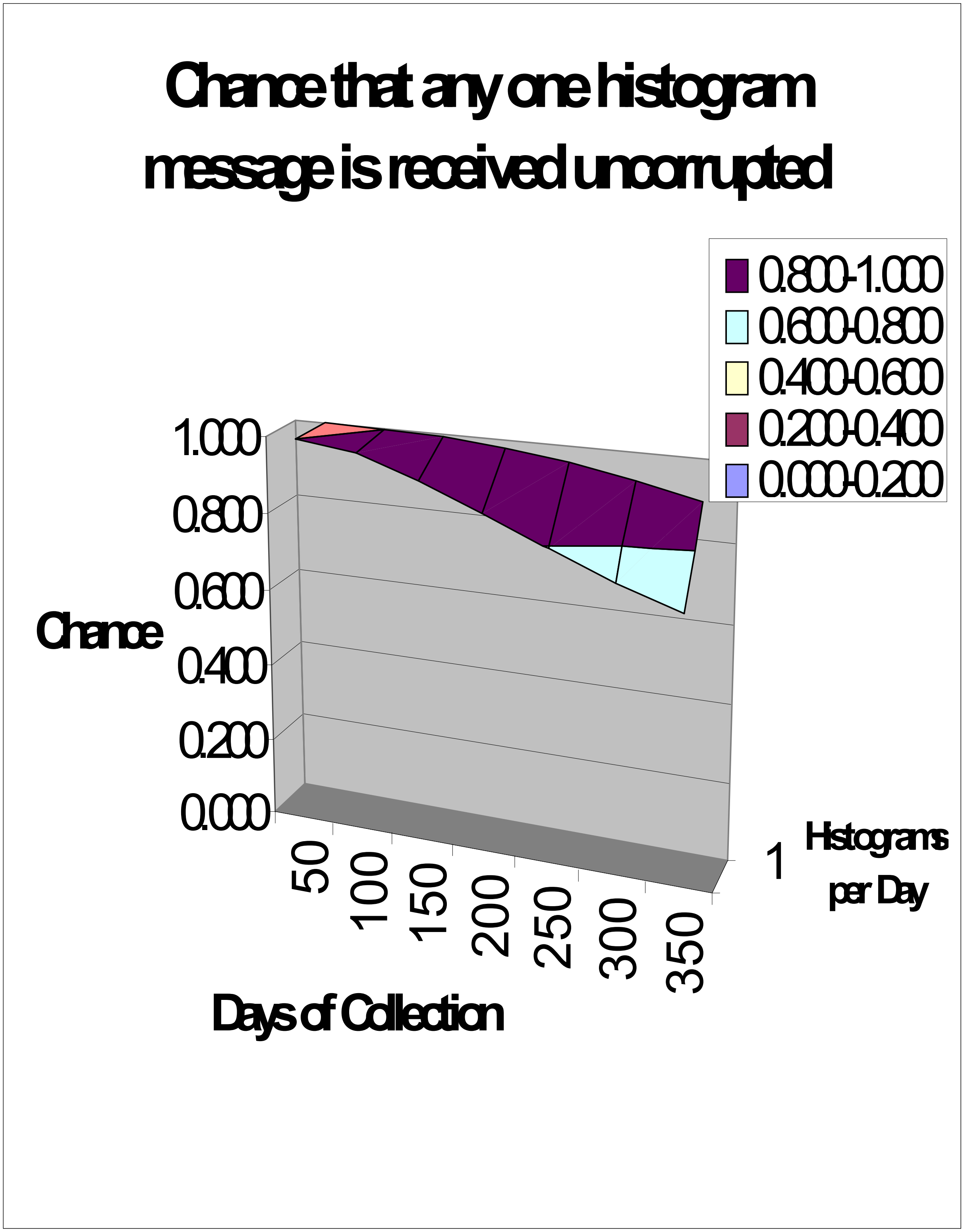

Figure 5. **Expected probability of a PAT tag histogram message being received uncorrupted as a function of duration and summarization interval when transmission priorities are: histograms-high, PDT tables-low, and location data-none.**

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June 7, 2002

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EDUCATION AND TRAINING

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B.S. Zoology and Biological Science (Marshall University, 1976)
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SCUBA (YMCA, Charleston, W.Va., 1975)
Intermediate Easytrieve (N.C. Dept. Admin., Raleigh, 1981)
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SAS Color Graphics (SAS Institute, Cary, N.C., 1983)
Surface Supplied Mixed Gas Diving (NOAA NURP, Univ. N. Carolina, Wilmington, 1984)
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PROFESSIONAL EMPLOYMENT

National Marine Fisheries Service, Southeast Fisheries Science Center

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Program manager and team leader for sea turtle research within SEFSC.

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Apr. 1988 - June 1998: Developed and implemented a multi-project plan to assess sea turtle distribution and abundance in inshore waters of the southeast
Sep. 1985 - Apr. 1988: Developed new techniques for aging juvenile fish, conducted studies on daily age and growth of populations of juvenile menhaden, and conducted population identification studies on Atlantic menhaden.

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Jan. 1981 - Aug. 1984: Designed, organized and conducted finfish and crustacean stock assessment surveys of NC estuarine waters, tagging projects, and age and growth projects; Assimilated and analyzed fisheries data from the Pamlico-Albemarle Peninsula to assess potential impacts of coastal energy development on the fisheries of the Peninsula.

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Designed and conducted a subpopulation identification study of Atlantic menhaden using meristics, morphometrics and biochemistry.

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Turtle Expert Working Group, 1995-1999.
NMFS Sea Turtle Review Panel for allocation of RPS funds, 1996-present.
Co-compiler of the Proceedings of the 17th Annual Sea Turtle Symposium, 1997-1998.
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HONORS AND AWARDS

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Peer-Reviewed Publications

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Epperly, S. P. 1989. A meristic, morphometric and biochemical investigation of Atlantic menhaden, *Brevoortia tyrannus* (Latrobe). Journal of Fish Biology 35:139-152.

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Myers, R.A., L. Gerber, L. Crowder, M. James, and S. Epperly. In press. Synthesis of observer, logbook, and research sighting survey data to estimate fishing impacts on loggerhead and leatherback turtles in the Northwest Atlantic. Proceedings of the 21st Annual Sea Turtle Symposium, February 24-28, 2001. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-SEFSC.

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CURRICULUM VITAE
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PRESENT POSITION

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ACADEMIC DEGREES

1967 B.S. with Honors in the Biological Sciences from Union College, Schenectady, NY.
1986 Ph.D. in Zoology from the University of Florida, Gainesville.

GRANTS AND CONTRACTS

Since joining the faculty at the University of Florida in 1989, I have served as principal or co-principal investigator on grants and contracts totaling over 4.5 million dollars. Most of the funding support has come from federal agencies and from non-governmental organizations. Most of these projects have involved various aspects of the biology of sea turtles.

SERVICE TO THE PROFESSION

1983-1985	Vice-President, American Association of Professional Apiculturists
1989-present	Marine Turtle Specialist Group of the International Union for the Conservation of Nature, Switzerland.
1989-present	Editorial Board for *Arquipélago*, a journal of life and marine sciences published by the University of the Azores
1991-1994	Scientific Advisory Panel for the joint National Marine Fisheries Service - Minerals Management Service sea turtle program in the Gulf of Mexico
1994-2000	Steering Committee, The Florida Biotic Information Consortium
1994-present	Scientific Advisor to Council of the Bahamas National Trust
1996-1998	Advisor to The Bahamas Environment, Science and Technology Commission in the Office of the Prime Minister to develop The Bahamas National Biodiversity Database, Strategy and Action Plan
1996-present	Scientific Advisory Committee, Caribbean Conservation Corp., Gainesville, FL
1997-2002	Chair, Scientific Advisory Committee, Bahamas National Trust

PROFESSIONAL SOCIETIES

American Association for the Advancement of Science, American Society of Ichthyologists and Herpetologists, Ecological Society of America (Life Member), Phi Kappa Phi Honor Society, Sigma Xi (Life Member), Society for Conservation Biology

PROCEEDINGS, EDITED OR COMPILED

1. Bjorndal, K.A., A.B. Bolten, D.A. Johnson and P.J. Eliazar (compilers). 1994. Proceedings of the Fourteenth Annual Symposium on Sea Turtle Biology and Conservation. NOAA Technical Memorandum NMFS-SEFSC-351. 323 pages.

2. Bolten, A.B., J.A. Wetherall, G.H. Balazs and S.G. Pooley (compilers). 1996. Status of marine turtles in the Pacific Ocean relevant to incidental take in the Hawaii-based pelagic longline fishery. NOAA Technical Memorandum NOAA-TM-NMFS-SWFSC-230. 167 pages.

3. Bolten, A.B., H.R. Martins, and K.A. Bjorndal (editors). 2000. Proceedings of a workshop to design an experiment to determine the effects of longline gear modification on sea turtle bycatch rates [*Workshop para a elaboração de uma experiência que possa diminuir as capturas acidentais de tartarugas marinhas nos Açores*], 2-4 September 1998, Horta, Azores, Portugal. NOAA Technical Memorandum NMFS-OPR-19. 50 pages. Bilingual.

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2. Bjorndal, K.A. and A.B. Bolten. 1990. Goals for sea turtle research in the Gulf of Mexico with respect to the oil and gas industries. Pages 47-58 in Sea turtles and marine mammals of the Gulf of Mexico, Proceedings of a workshop held in New Orleans, 1-3 August 1989. OCS Study MMS 90-0009, Minerals Management Service, U.S. Department of the Interior, New Orleans.

3. Bolten, A.B., K.A. Bjorndal and H.R. Martins. 1994. Life history model for the loggerhead sea turtle (*Caretta caretta*) population in the Atlantic: Potential impacts of a longline fishery. Pages 48-54 in G.H. Balazs and S.G. Pooley (eds.), Research Plan to Assess Marine Turtle Hooking Mortality: Results of an Expert Workshop Held in Honolulu, Hawaii, November 16-18, 1993. NOAA Technical Memorandum NMFS-SWFSC-201.

4. Bolten, A.B. and G.H. Balazs. 1995. Biology of the early pelagic stage--the "lost year." Pages 575-581 in K.A. Bjorndal (ed.), Biology and conservation of sea turtles, revised

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5. Bolten, A.B., K.A. Bjorndal and H.R. Martins. 1995. Life history of the loggerhead sea turtle, *Caretta caretta* (Reptilia: Cheloniidae), in the Atlantic. In A. Domingo Abreu and M. Biscoito (eds.), Proceedings of the First Symposium Fauna and Flora of Atlantic Islands. Boletim do Museu Municipal do Funchal, Madeira, Portugal, Sup. no. 4:115-122.

6. Bolten, A.B. 1999. Techniques for measuring sea turtles. Pages 110-114 in K.L. Eckert, K.A. Bjorndal, F.A. Abreu Grobois and M. Donnelly (editors). Management and Research Techniques for the Conservation of Sea Turtles. IUCN, Gland, Switzerland.

7. Bjorndal, K.A. and A.B. Bolten. 2000. Green turtles at Conception Island Creek, Bahamas. Pages 75-76 in K.A. Bjorndal and A.B. Bolten (editors), Proceedings of a workshop on assessing abundance and trends for in-water sea turtle populations. NOAA Technical Memorandum NMFS-SEFSC-445.

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2. Mori, S.A., G.T. Prance and A.B. Bolten. 1978. Additional notes on the floral biology of neotropical Lecythidaceae. Brittonia 30:113-130.

3. Bolten, A.B. and P. Feinsinger. 1978. Why do hummingbird flowers secrete dilute nectar? Biotropica 10:307-309.

4. Bolten, A.B., P. Feinsinger, H.G. Baker and I. Baker. 1979. On the calculation of sugar concentration in flower nectar. Oecologia 41:301-304.

5. Harbo, J.R. and A.B. Bolten. 1981. Development times of male and female eggs of the honey bee. Annals of the Entomological Society of America 74:504-506.

6. Harbo, J.R., A.B. Bolten, T.E. Rinderer and A.M. Collins. 1981. Development periods for eggs of Africanized and European honeybees. Journal of Apicultural Research 20:156-159.

7. Rinderer, T.E., A.M. Collins, A.B. Bolten and J.R. Harbo. 1981. Size of nest cavities selected by swarms of Africanized honeybees in Venezuela. Journal of Apicultural Research 20:160-164.

8. Bolten, A.B. and J.R. Harbo. 1982. Numbers of spermatozoa in the spermatheca of the queen honeybee after multiple insemination with small volumes of semen. Journal of Apicultural Research 21:7-10.

9. Rinderer, T.E., A.B. Bolten, J.R. Harbo and A.M. Collins. 1982. Hoarding behavior of European and Africanized honey bees (Hymenoptera: Apidae). Journal of Economic Entomology 75:714-715.

10. Collins, A.M., T.E. Rinderer, J.R. Harbo and A.B. Bolten. 1982. Colony defense by Africanized and European honey bees. Science 218:72-74.

11. Sylvester, H.A., T.E. Rinderer and A.B. Bolten. 1983. Honey-sac contents: A technique for collection and measurement in foraging honey bees (Hymenoptera: Apidae). Journal of Economic Entomology 76:204-206.

12. Bolten, A.B., F.A. Robinson, J.L. Nation and S.J. Yu. 1983. Food sharing between honeybee colonies in flight cages. Journal of Apicultural Research 22:98-100.

13. Carlson, D.A. and A.B. Bolten. 1984. Identification of Africanized and European honey bees using extracted hydrocarbons. Bulletin of the Entomological Society of America 30:32-35.

14. Rinderer, T.E., A.B. Bolten, A.M. Collins and J.R. Harbo. 1984. Nectar foraging characteristics of Africanized and European honeybees in the neotropics. Journal of Apicultural Research 23:70-79.

15. Nation, J.L., F.A. Robinson, S.J. Yu and A.B. Bolten. 1986. Influence upon honeybees of chronic exposures to very low levels of selected insecticides in their diet. Journal of Apicultural Research 25:170-177.

16. Bjorndal, K.A. and A.B. Bolten. 1988. Growth rates of immature green turtles, *Chelonia mydas*, on their feeding grounds in the southern Bahamas. Copeia 1988:555-564.

17. Bjorndal, K.A. and A.B. Bolten. 1988. Growth rates of loggerheads, *Caretta caretta*, in the southern Bahamas. Journal of Herpetology 22:480-482.

18. Bjorndal, K.A. and A.B. Bolten. 1989. Comparison of straight-line and over-the-curve measurements for growth rates of green turtles, *Chelonia mydas*. Bulletin of Marine Science 45:189-192.

19. Bjorndal, K.A. and A.B. Bolten. 1990. Digestive processing in a herbivorous freshwater turtle: Consequences of small-intestine fermentation. Physiological Zoology 63:1232-1247.

20. Bjorndal, K.A., A.B. Bolten and J.E. Moore. 1990. Digestive fermentation in herbivores: Effect of food particle size. Physiological Zoology 63:710-721.

21. Bjorndal, K.A., H. Suganuma and A.B. Bolten. 1991. Digestive fermentation in green turtles, *Chelonia mydas*, feeding on algae. Bulletin of Marine Science 48:166-171.

22. Guillette, L.J., Jr., K.A. Bjorndal, A.B. Bolten, T.S. Gross, B.D. Palmer, B.E. Witherington and J. Matter. 1991. Plasma estradiol-17ß, progesterone, prostaglandin F, and prostaglandin E_2 concentrations during natural oviposition in the loggerhead turtle (*Caretta caretta*). General and Comparative Endocrinology 82:121-130.

23. Bjorndal, K.A. and A.B. Bolten. 1992. Body size and digestive efficiency in a herbivorous

freshwater turtle: advantages of small bite size. Physiological Zoology 65:1028-1039.

24. Bjorndal, K.A. and A.B. Bolten. 1992. Spatial distribution of green turtle (*Chelonia mydas*) nests at Tortuguero, Costa Rica. Copeia 1992:45-53.

25. Bolten, A.B. and K.A. Bjorndal. 1992. Blood profiles for a wild population of green turtles (*Chelonia mydas*) in the southern Bahamas: size-specific and sex-specific relationships. Journal of Wildlife Diseases 28:407-413.

26. Bolten, A.B., K.A. Bjorndal, J.S. Grumbles and D.W. Owens. 1992. Sex ratio and sex-specific growth rates in immature green turtles, *Chelonia mydas*, in the southern Bahamas. Copeia 1992:1098-1103.

27. Bolten, A.B., E.R. Jacobson and K.A. Bjorndal. 1992. Effects of anticoagulant and autoanalyzer on blood biochemical values of loggerhead sea turtles (*Caretta caretta*). American Journal of Veterinary Research 53:2224-2227.

28. Bjorndal, K.A. and A.B. Bolten. 1993. Digestive efficiencies in herbivorous and omnivorous freshwater turtles on plant diets: do herbivores have a nutritional advantage? Physiological Zoology 66:384-395.

29. Bjorndal, K.A., A.B. Bolten and C.J. Lagueux. 1993. Decline of the nesting population of hawksbill turtles at Tortuguero, Costa Rica. Conservation Biology 7:925-927.

30. Bolten, A.B., H.R. Martins, K.A. Bjorndal and J. Gordon. 1993. Size distribution of pelagic-stage loggerhead sea turtles (*Caretta caretta*) in the waters around the Azores and Madeira. Arquipélago 11A:49-54.

31. Allard, M.W., M.M. Miyamoto, K.A. Bjorndal, A.B. Bolten and B.W. Bowen. 1994. Support for natal homing in green turtles from mitochondrial DNA sequences. Copeia 1994:34-41.

32. Bjorndal, K.A., A.B. Bolten and C.J. Lagueux. 1994. Ingestion of marine debris by juvenile sea turtles in coastal Florida habitats. Marine Pollution Bulletin 28:154-158.

33. Lahanas, P.N., M.M. Miyamoto, K.A. Bjorndal and A.B. Bolten. 1994. Molecular evolution and population genetics of Greater Caribbean green turtles (*Chelonia mydas*) as inferred from mitochondrial DNA control region sequences. Genetica 94:57-67.

34. Bjorndal, K.A. and A.B. Bolten. 1995. Comparison of length-frequency analyses for estimation of growth parameters for a population of green turtles. Herpetologica 51:160-167.

35. Bjorndal, K.A., A.B. Bolten, A.L. Coan, Jr. and P. Kleiber. 1995. Estimation of green turtle (*Chelonia mydas*) growth rates from length-frequency analysis. Copeia 1995:71-77.

36. Crain, D.A., A.B. Bolten and K.A. Bjorndal. 1995. Effects of beach nourishment on sea turtles: Review and research initiatives. Restoration Ecology 3:95-104.

37. Crain, D.A., A.B. Bolten, K.A. Bjorndal, L.J. Guillette, Jr. and T.S. Gross. 1995. Size-dependent, sex-dependent, and seasonal changes in insulin-like growth factor I in the loggerhead sea turtle (*Caretta caretta*). General and Comparative Endocrinology 98:219-226.

38. Gross, T.S., D.A. Crain, K.A. Bjorndal, A.B. Bolten and R.R. Carthy. 1995. Identification of sex in hatchling loggerhead turtles (*Caretta caretta*) by analysis of steroid concentrations in chorioallantoic fluid. General and Comparative Endocrinology 99:204-210.

39. Lagueux, C.J., K.A. Bjorndal, A.B. Bolten and C.L. Campbell. 1995. Food habits of *Pseudemys concinna suwanniensis* in a Florida spring. Journal of Herpetology 29:122-126.

40. Bjorndal, K.A., A.B. Bolten, C.J. Lagueux and A. Chaves. 1996. Probability of tag loss in green turtles nesting at Tortuguero, Costa Rica. Journal of Herpetology 30:566-571.

41. Bowen, B.W., A.L. Bass, A. Garcia-Rodriguez, C.E. Diez, R. van Dam, A.B. Bolten, K.A. Bjorndal, M.M. Miyamoto and R.J. Ferl. 1996. Origin of hawksbill turtles in a Caribbean feeding area as indicated by genetic markers. Ecological Applications 6:566-572.

42. Encalada, S.E., P.N. Lahanas, K.A. Bjorndal, A.B. Bolten, M.M. Miyamoto and B.W. Bowen. 1996. Phylogeography and population structure of the Atlantic and Mediterranean green turtle *Chelonia mydas*: a mitochondrial DNA control region sequence assessment. Molecular Ecology 5:473-483.

43. Gregory, L.F., T.S. Gross, A.B. Bolten, K.A. Bjorndal and L.J. Guillette, Jr. 1996. Plasma corticosterone concentrations associated with acute captivity stress in wild loggerhead sea turtles (*Caretta caretta*). General and Comparative Endocrinology 104:312-320.

44. Johnson, S.A., K.A. Bjorndal and A.B. Bolten. 1996. Loggerhead turtle (*Caretta caretta*) nesting behavior and hatchling production in Florida: effects of organized turtle watches. Conservation Biology 10:570-577.

45. Johnson, S.A., K.A. Bjorndal and A.B. Bolten. 1996. A survey of organized turtle watch participants on sea turtle nesting beaches in Florida. Chelonian Conservation and Biology 2:60-65.

46. Bjorndal, K.A., A.B. Bolten, C.J. Lagueux and D.R. Jackson. 1997. Dietary overlap in three sympatric congeneric freshwater turtles (*Pseudemys*) in Florida. Chelonian Conservation and Biology 2:430-433.

47. Bjorndal, K.A., A.B. Bolten, R.A. Bennett, E.R. Jacobson, T.J. Wronski, J.J. Valeski and P.J. Eliazar. 1998. Age and growth in sea turtles: limitations of skeletochronology for demographic studies. Copeia 1998:23-30.

48. Bolten, A.B., K.A. Bjorndal, H.R. Martins, T. Dellinger, M.J. Biscoito, S.E. Encalada and B.W. Bowen. 1998. Transatlantic developmental migrations of loggerhead sea turtles demonstrated by mtDNA sequence analysis. Ecological Applications 8:1-7.

49. Bouchard, S., K. Moran, M. Tiwari, D. Wood, A. Bolten, P. Eliazar and K. Bjorndal. 1998. Effects of exposed pilings on sea turtle nesting activity at Melbourne Beach, Florida. Journal of Coastal Research 14:1343-1347.

50. Encalada, S.E., K.A. Bjorndal, A.B. Bolten, J.C. Zurita, B. Schroeder, E. Possardt, C.J. Sears and B.W. Bowen. 1998. Population structure of loggerhead turtle (*Caretta caretta*) nesting colonies in the Atlantic and Mediterranean as inferred from mitochondrial DNA control region sequences. Marine Biology 130:567-575.

51. Lahanas, P.N., K.A. Bjorndal, A.B. Bolten, S.E. Encalada, M.M. Miyamoto, R.A. Valverde and B.W. Bowen. 1998. Genetic composition of a green turtle (*Chelonia mydas*) feeding ground population: evidence for multiple origins. Marine Biology 130:345-352.

52. Bjorndal, K.A., J.A. Wetherall, A.B. Bolten and J.A. Mortimer. 1999. Twenty-six years of green turtle nesting at Tortuguero, Costa Rica: an encouraging trend. Conservation Biology 13:126-134.

53. Moran, K.L., K.A. Bjorndal and A.B. Bolten. 1999. Effects of the thermal environment on the temporal pattern of emergence of hatchling loggerhead turtles (*Caretta caretta*). Marine Ecology Progress Series 189:251-261.

54. Bjorndal, K.A., A.B. Bolten and M.Y. Chaloupka. 2000. Green turtle somatic growth model: evidence for density dependence. Ecological Applications 10:269-282.

55. Bjorndal, K.A., A.B. Bolten and H.R. Martins. 2000. Somatic growth model of juvenile loggerhead sea turtles *Caretta caretta*: duration of pelagic stage. Marine Ecology Progress Series 202:265-272.

56. Bjorndal, K.A., A.B. Bolten, B. Koike, B.A. Schroeder, D.J. Shaver, W.G. Teas, and W.N. Witzell. 2001. Somatic growth function for immature loggerhead sea turtles in southeastern U.S. waters. Fishery Bulletin 99:240-246.

57. Ferreira, R.L., H.R. Martins, A.A. da Silva, and A.B. Bolten. 2001. Impact of swordfish fisheries on sea turtles in the Azores. Arquipélago 18A:75-79.

58. Schmid, J.R., A.B. Bolten, K.A. Bjorndal, and W.J. Lindberg. 2002. Activity patterns of Kemp's ridley turtles, *Lepidochelys kempii*, in the coastal waters of the Cedar Keys, Florida. Marine Biology 140:215-228.

NON-REFEREED PUBLICATIONS

This list does not include > 50 published abstracts from presentations

1. Bjorndal, K.A. and A.B. Bolten. 1978. Union Creek--A look to the future. The Bahamas Naturalist 4:18-22, 27.

2. Bolten, A.B. and K.A. Bjorndal. 1987. Procedures manual for the marine turtle tagging team at Tortuguero. Center for Sea Turtle Research, Gainesville, FL, 37 pages.

3. Bolten, A.B. and H.R. Martins. 1990. Kemp's ridley captured in the Azores. Marine Turtle Newsletter 48:23.

4. Bolten, A.B., H.R. Martins, M.L. Natali, J.C. Thomé and M.A. Marcovaldi. 1990. Loggerhead released in Brazil recaptured in Azores. Marine Turtle Newsletter 48:24-25.

5. Bolten, A.B., H.R. Martins, K.A. Bjorndal, M. Cocco and G. Gerosa. 1992. *Caretta caretta* (loggerhead) pelagic movement and growth. Herpetological Review 23:116.

6. Bolten, A.B., Santana, J.C. and K.A. Bjorndal. 1992. Transatlantic crossing by a loggerhead turtle. Marine Turtle Newsletter 59:7-8.

7. Bjorndal, K.A., A.B. Bolten, J. Gordon and J.A. Camiñas. 1994. *Caretta caretta* (loggerhead) growth and pelagic movement. Herpetological Review 25:23-24.

8. Bolten, A.B., K.A. Bjorndal, P.J. Eliazar and L.F. Gregory. 1994. Seasonal abundance, size distribution, and blood biochemical values of loggerheads (*Caretta caretta*) in Port Canaveral Ship Channel, Florida. NOAA Technical Memorandum NMFS-SEFSC-353. 39 pages.

9. Bjorndal, K.A. and A.B. Bolten. 1998. Hawksbill tagged in the Bahamas recaptured in Cuba. Marine Turtle Newsletter 79:18-19.

10. Eliazar, P.J., K.A. Bjorndal and A.B. Bolten. 2000. Early report of fibropapilloma from St. Croix, USVI. Marine Turtle Newsletter 89:16.

RESUME

ERIC D. PRINCE

BUSINESS ADDRESS

Fishery Research Biologist, GS-14
National Marine Fisheries Service, NOAA
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HOME ADDRESS

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Phone: (305) 598-0944

Birthdate: October 10, 1946
SSN: 573-64-8531
Health: Excellent
Height: 6 feet
Weight: 200 lbs
Marital Status: Married (Jill) with two children, Pierce 18 yr,
Kimberly 13 yr.

EDUCATION

Virginia Polytechnic Institute and State University
Blacksburg, VA 24061
Ph.D. in Fisheries and Wildlife Sciences
May 1977

Humboldt State University
Arcata, CA 95521
M.S. in Fisheries (marine)
December 1972

University of the Pacific
Stockton, CA 95204
B.S. in Biology (marine)
June 1969

PROFESSIONAL EXPERIENCE

1996-present
Fishery Research Biologist - GS-14
Chief, Migratory Fishery Biology Branch
U.S. Department of Commerce
National Marine Fisheries Service
Southeast Fisheries Center, Miami Laboratory
75 Virginia Beach Drive, Miami, FL 33149
Chief, Sustainable Fishery Resources Division: Dr. Gerry Scott
Job Description:

Chief, Migratory Fishery Biology Branch of the Sustainable Fishery Resources Division. Primary duties include: Coordination of the ICCAT Enhanced Research Program for Billfish in the Western Atlantic Ocean; supervise the domestic billfish tournament surveys in the south Atlantic, Gulf of Mexico, and Caribbean Sea; director of the Cooperative Tagging Center. Act as rappatour for billfish at ICCAT and take the lead in accomplishing stock assessments of istiophoridae in the Atlantic Ocean and defend assessments through domestic and international reviews. Coordinate the ICCAT Enhanced Research Program for Billfish in the Western Atlantic Ocean. Direct activities of all Branch Staff, responsible for Branch budget and administration duties.

1991-1996
Supervisory Fishery Research Biologist - GS-14
Chief, Migratory Fishery Biology Division
U.S. Department of Commerce
National Marine Fisheries Service
Southeast Fisheries Center, Miami Laboratory
75 Virginia Beach Drive, Miami, FL 33149
Director, Southeast Fisheries Center, Dr. Brad Brown
Job Description:

Chief, Migratory Fishery Biology Division of the Miami Laboratory. Primary duties include: Coordination of the ICCAT Enhanced Research Program for Billfish in the Western Atlantic Ocean; supervise the domestic billfish tournament surveys in the south Atlantic, Gulf of Mexico, and Caribbean Sea; director of the Cooperative Tagging Center. Act as rappatour for billfish at ICCAT and take the lead in accomplishing stock assessments of istiophoridae in the Atlantic Ocean and defend assessments through domestic and international reviews. Coordinate the ICCAT Enhanced Research Program for Billfish in the Western Atlantic Ocean. Direct activities of all Division Staff, responsible for Division budget and administration duties.

1986-1991
Fishery Research Biologist - GS-13
U.S. Department of Commerce
National Marine Fisheries Service
Southeast Fisheries Center, Miami Laboratory
75 Virginia Beach Drive, Miami, FL 33149

Director, Southeast Fisheries Center: Dr. Brad Brown
Job Description:

Coordinator for the Western Atlantic Ocean, ICCAT Enhanced Research Program for Billfish. Develop overall program plan and sampling scheme for Caribbean Island Nations, oversee sampling, hire samplers and contractors, provide quarterly highlight reports for all program interest groups, assist funding of program, and develop annual reports and working documents for ICCAT. Supervise retrieval, inventory, diagnostic examination, and quality control of Atlantic wide landings, size frequency, and CPUE data sets for Istiophoridae, conduct research on age/growth and other life history aspects of billfish. Act as billfish rapporteur for ICCAT (since 1983).

1982-1986
Fishery Research Biologist - GS-13
U.S. Department of Commerce
National Marine Fisheries Service, NOAA
Southeast Fisheries Center, Miami Laboratory
75 Virginia Beach Drive
Miami, FL 33149
Chief, Oceanic Resources Division: Dr. Grant Beardsley (till 1985) then Mr. M. Parrack (till 11/86) Job Description:

Fisheries Analysis Team Leader. Act as rating official, provide technical guidance, and supervise activities of the 7-9 members of the Fisheries Analysis Team. Major areas of emphasis include: (1) Cooperative Game-fish Tagging Program; (2) Sport Catch/Effort Surveys (billfish and tuna); and (3) Age and growth research on Oceanic Pelagic Fishes. Prepared Fisheries Analysis Program plans and project budgets, and monitored progress of numerous contracts with outside agencies. Developed new research proposals and cooperative research agreements with other federal agencies and universities to meet goals of Fisheries Analysis program. Cooperated with other members of the Division to develop working papers for ICCAT. Other activities include acting as convener and senior editor of an international workshop on age determination of oceanic pelagic fishes and underwater projects as a NOAA authorized SCUBA diver.

1984 - present
Adjunct Associate Professor
Rosenstiel School of Marine and Atmospheric Sciences
University of Miami
4600 Rickenbacker Causeway
Miami, Florida 33149
Job Description:

Participate on graduate student committees, guest lecturer for university seminars, and share teaching responsibilities (see below) as required. Co-chairman on graduate committee of Jeff Tellock (masters degree candidate), project on age and growth of larval snook completed spring 1989. Presently Co-chairman on graduate committee (with Nelson Ehrhardt) of Christopher Jones (Ph.D. candidate), project on performance, uncertainties, and management implications of dart tags on red snapper and red drum (this project is a CUPERS project). Participated on 5 other graduate committees, including the graduate committee of Freddy Arocha.

1981-1983
Adjunct Assistant Professor
Rosenstiel School of Marine and Atmospheric Sciences
University of Miami
4600 Rickenbacker Causeway
Miami, FL 33149
Job Description:

Participant on graduate student committees and guest lecturer for university seminars. Shared teaching responsibilities for Introduction to Fisheries (BLR 509) Fall 1981 and 1982, Fisheries Seminar (BLR 601) Spring 1984, Fisheries Biology Laboratory Fall 1990.

1980-1982
Fishery Research Biologist - GS-12
U.S. Department of Commerce
National Marine Fisheries Service, NOAA
Southeast Fisheries Center, Miami Laboratory
75 Virginia Beach Drive
Miami, FL 33149
Laboratory Director: Dr. W. J. Richards
Job Description:

Conduct bioprofiles studies on tuna and billfishes, principally investigating age and reproductive biology. Also conduct and supervise field studies of tagging bluefin tuna, analyzing the results to determine movements, migrations and population sizes. Develop new tags and assess tag performance. Prepared project plans and developed new

research proposals with NMFS personnel, as well as other agencies. Technical supervisor for two permanent fishery biologists and one temporary biological technician.

1977-1980
Fishery Research Biologist - GS 11/3
U.S. Department of the Interior
Fish and Wildlife Service
Southeast Reservoir Investigations
206 Hwy, 123 By-Pass Clemson, SC 29631
Chief: Dr. J. P. Clugston
Job Description:

Population dynamics project leader. Responsibilities include determining the effects of heated effluent and pumped storage operations on the distribution, growth, reproductive success, production, and mortality of major prey and predatory fishes in the study reservoirs. Technical supervisor of one permanent fisheries biologist and one temporary field technician. Prepared project budgets and developed new research proposals with other agencies. Consultant to other agencies, providing environmental impact review and recommendations. Participant on several graduate student committees, including review and oral defense of thesis.

SOCIETIES, CERTIFICATIONS, AND SPECIAL SKILLS

American Fisheries Society (Since 1968)
Member, Student Affairs Committee, A.F.S., 1975-1976
Virginia Tech Chapter American Fisheries Society, 1972-1976
Member, Program Committee, Southeastern Section A.F.S., 1978
Certified Fisheries Scientist, A.F.S., No. 1247, 1978
American Institute of Fishery Research Biologists (AIFRB)
Associate Status 1976, Member Status 1977, Fellow Status 1991
Florida District AIFRB
Fishery Environmental Advisory Committee, 1980-1981
Vice-Director and Program Chairman, 1981-1983
Director of Florida District AIFRB, 1983-1986
South Carolina Fisheries Workers Association, 1977-1978
Coastal Society (Charter Member, 1976)
Society of Sigma Xi
Phi Sigma Society
Certified General SCUBA Diver No. 003175 (L.A. County Underwater Inst. Association) 1969
Certified Sport SCUBA Diver No. 5-6606 (Nat. Assoc. of Underwat. Inst., NAUI), 1975
Authorized SCUBA Diver, U.S. Department of Interior, Fish & Wildlife Service, Clemson, South Carolina, 1978-1980
Authorized SCUBA Diver, U.S. Department of Commerce, NOAA, Miami Laboratory, Miami, Florida, 1981-1986
United States Coast Guard Captain's License to operate commercial boats < 15 tons, serial number 183011, June 1981, second issue June 1986
Underwater Photographer 1972-present

HONORS AND AWARDS

Department of Commerce..............Cash Performance Award, National Marine Fisheries Service, 75 Virginia Beach Drive, Miami, FL. October 2001.

Department of Commerce..............Cash Performance Award, National Marine Fisheries Service

75 Virginia Beach Drive, Miami, FL. October 2000.

Department of Commerce..............Outstanding Performance, National Marine Fisheries Service 75 Virginia Beach Drive, Miami, FL. October 1999.

The Computerworld Awards...........**Smithsonian Institute Laureate** for 1999. Research group, NMFS and Stanford University's Tuna Research and Conservation Center. For "High-tech Archival tags." Washington, D.C. April 12, 1999.

Department of Commerce..............Special Service Award ($1,500), National Marine Fisheries Service, 75 Virginia Beach Drive, Miami, FL 33149 May 1997

Department of Commerce.............Outstanding Performance, National Marine Fisheries Service 75 Virginia Beach Dr., Miami, FL 33149 October 1997

Department of Commerce.............Outstanding Performance, National Marine Fisheries Service, 75 Virginia Beach Dr., Miami, FL 33149 October 1996

Individual Scientific Achievement Award...........The Billfish Foundation, 2419 East Commercial Blvd., Fort Lauderdale, FL 33308. October, 1995

Lokey Distinguished Lecturer........Texas Tech University, .Dept. Range & Wildlife Ecology, Fisheries, & Management. Lubbock, TX. Honorarium/Travel Expenses. April 12-14, 1994

Research Award.....................National Fish and Wildlife Foundation, ICCAT Enhanced Research Program for Billfish, 1120 Connecticut Ave. NW, Bender Building, Suite 900, Washington, DC July 1993
Department of Commerce.............Outstanding performance, National Marine Fisheries Service, Miami Laboratory, Miami, Florida May 1991.

Department of Commerce..............Outstanding Performance, National Marine Fisheries Service, Miami Laboratory, Miami, Florida, July 1990.

Certificate of Appreciation Award..................The Billfish Foundation, Chairman of the Scientific Committee, 1986-1990. May 1990.

Travel Award........................American Fisheries Society, International Symposium and Workshop on Creel and Angler Surveys in Fisheries. Invited Speaker, March 27-31, 1989. Houston, TX

Travel Award........................American Fisheries Society, International Symposium and Workshop on Fish Marking Techniques. Program and steering committees,, Seattle, WA June 27 to July 1, 1988.

Department of Commerce..............Outstanding performance, National Marine Fisheries Service, Miami Laboratory, Miami, FL, July 1986.

Award of Excellence..................International Society for Pacific Northwest Technical Competitions to Lee Thorson as Managing Editor. January 1985, Report 8 "Proceedings of the International Workshop on Age Determination of Oceanic Pelagic Fishes: Tunas, Billfishes, and Sharks." Eric D. Prince (Convener and Senior Editor) and Lynn M. Pulos (Editor).

Department of Commerce...............Outstanding performance, National Marine Fisheries Service, Miami Laboratory, Miami, FL, July 1984.

Department of Commerce...............Outstanding Performance, National Marine Fisheries Service, Miami Laboratory Miami, FL, October 1983

Department of Commerce..............Special Service Award, Senior Edito and Convener, Proceedings of the International Workshop on Age Determination of Oceanic Pelagic Fishes, October 1983.

Department of Commerce.............Outstanding Performance, National Marine Fisheries Service, Miami Laboratory, Miami, FL, April 1982

Photographic Award..................U.S. Fish and Wildlife Service photo Contest, Category - Fish Region 4, 1978

Commendation Award..................Contribution to the International Symposium on Predator Prey Systems in Fish Communities and their role in Fisheries Mgmt., Volunteer paper 1978. Sport Fishing Institute, Washington, D.C.

Commendation Award..................Contribution to the First National Bass Symposium, Senior Author for contributed paper 1975, Sport Fishing Institute, Washington, D.C.

Outstanding Ph.D. Candidate Award..........Virginia Tech Chapter of American Fisheries Society 1975, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061

Research Assistantship..............Department of Fisheries and Wildlife Sciences 1975, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061

Research Grant......................Virginia Commission of Game and Inland Fisheries and the U.S. Department of the Interior, Federal Aid to Fish & Wildlife Restoration (Dingell-Johnson Project Va-F-31-R). 1973-1976 Richmond, VA 23230

Academic Scholarship.........................Graduate State Tuition Scholarship, 1975 Virginia Polytechnic Institute and State, University, Blacksburg, VA 24061

Football Scholarship.........................Department of Intercollegiate Athletics 1966-1968, University of the Pacific, Stockton, CA 95204

EDITORIAL AND COMPILATION ACTIVITIES (for Journals, Symposia, and ICCAT)

Proceedings of the Fourth ICCAT Billfish Workshop. 2001. Rappatour and chairman of the ICCAT billfish working group. ICCAT Collective Volume of Scientific papers. 375 pp.

Proceedings of the Third International Billfish Symposium, Cairns, Australia, 2001. Program and Steering committees, session chairman. Marine and Freshwate Fisheries Journal (Australia).

Report of the Third ICCAT Billfish Workshop. 1996. Rappatour and chairman of the ICCAT billfish working group. ICCAT Collective Volume of Scientific papers. 352 pp.

Report of the Second ICCAT Billfish Workshop. 1992. Rappatour and chairman of the ICCAT billfish working group. ICCAT Collective Volume of Scientific papers. 587 pp.

Proceedings of the International Symposium and Workshop on Fish Marking Techniques, American Fisheries Society, Seattle, Washington, August 1988. Program and steering committee, session chairman and editor for section on external tags and marks (35 manuscripts with co-chairs S. McFarlane and R. Wydoski). AFS Symposium Series.

Proceedings of the Second International Billfish Symposium, Kona, Hawaii, 1988. Program committee, session chairman and editor for section on age and growth (11 manuscripts). Books, Planning the Future of Billfish Vols 1 & 2, National Coalition for Marine Conservation.

Proceedings of the International Symposium on Age and Growth of Fish, Des Moines, Iowa, 1985. Glossary committee. Book, Age and Growth of Fish. Iowa State University Press.

Sea Grant (on-site program review), Michigan State University and University of Michigan, 1983-84.

Proceedings of the International Workshop on Age Determination of Oceanic Pelagic Fishes: Tunas, Billfishes, and Sharks. Miami, Florida, February 15-18. 1982. Senior editor and convener. (28 manuscripts with L. Pulos junior editor). NOAA Technical Report.

Associate Editor, North American Journal of Fisheries Management, N.A.J.F.M., appointed 1981-1983.

PEER REVIEW PUBLICATIONS

RESTREPO, V., E. D. Prince, G. P. Scott, and Y. Uozumi. Submitted. ICCAT's stock assessments of Atlantic billfish. Proceedings of the Third International Billfish Symposium. Marine and Freshwater Fisheries Journal (CISRO, Australia). 14 pp.

ORTIZ, M., E. D. Prince, J. E. Serafy, D. B. Holts, K. B. Davy, J. G. Pepperell, M. B. Lowry, and J. C. Holdsworth. Submitted. A global overview of the major constituent-based billfish

tagging programs and their results since 1954. Proceedings of the Third International Billfish Symposium. Marine and Freshwater Fisheries Journal (CIRSO, Australia). 45 pp.

PRINCE, E. D., M. Ortiz, A. Venizelos, and D. S. Rosenthal. In press. In-water conventional tagging techniques developed by the cooperative tagging center for large highly migratory species. Proceedings of a Symposium on Catch and Release in Marine Recreational Fisheries. Virginia Beach, Virginia, December 1999. Amer. Fish. Soc. Symp. 17 pp.

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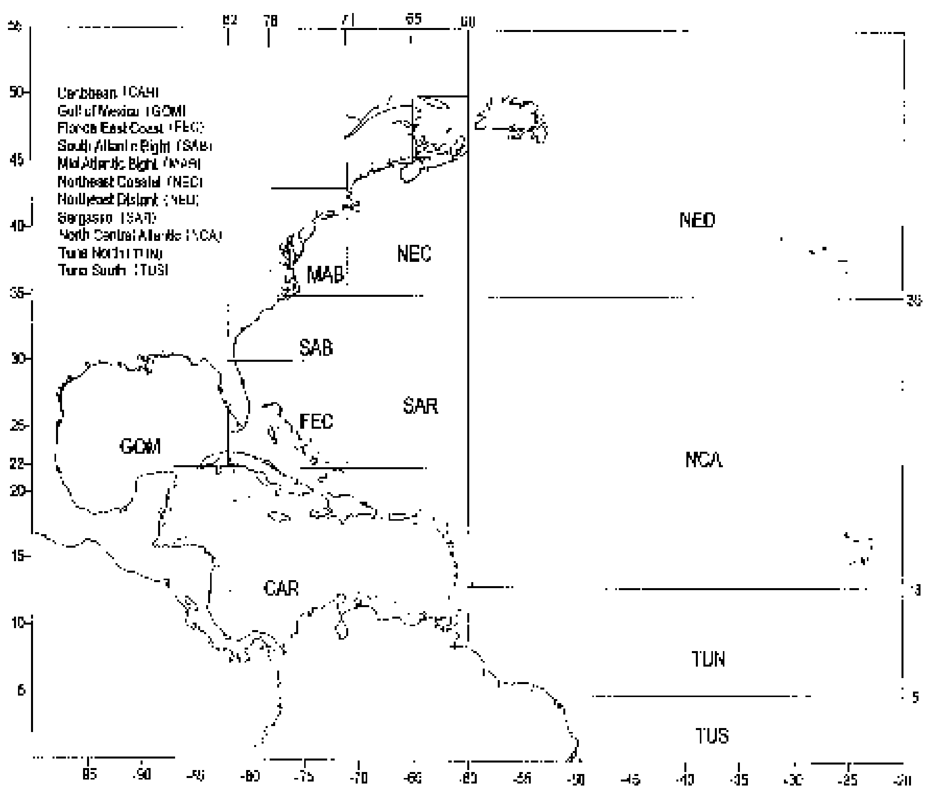
Appendix V. Proposed 2002 Experimental Design for the Grand Banks (NED) Experiments.

PROPOSED 2002 EXPERIMENTAL DESIGN FOR THE GRAND BANKS (NED)

The National Marine Fisheries Service proposes to conduct scientific research in consultation and cooperation with the commercial pelagic longline fleet in the Western North Atlantic to develop and evaluate the efficacy of new technologies and changes in fishing practices to reduce the incidental take and mortality of endangered and threatened sea turtle species by pelagic longline gear. This is the second year of the planned research and is scheduled to commence by July 8, 2002. At the completion of 3 years of research, the program will be evaluated and recommendations provided to fishery managers. NMFS is seeking authorization of this research through application of an ESA section 10 research and enhancement permit. The proposed research will utilize commercial fishing vessels as research platforms in the Northeast Distant (NED) statistical sampling area (Figure 1). Participating pelagic longline vessels that fish the NED must carry observers, and they must fish their gear in a specified, pre-determined manner designed to test one or more variables affecting sea turtle bycatch.

Figure 1 **Pelagic Longline Fishing Areas** Source: Cramer and Adams, 2000.



The results of analyses of experiments conducted in 2001 have determined that blue dyed bait and hook position relative to floats are ineffective in reducing sea turtle interaction with longline gear (Annual Report for NMFS ESA Section 10 Permit #1324, submitted March 27, 2002. Analysis of data collected in 2001 indicates that reduced daylight soak time has potential to significantly reduce loggerhead interaction with longline gear. Anecdotal information from the U.S. longline fishery and a recent report from the Canadian longline fishery indicate that mackerel bait has potential to reduce interaction of sea turtles with longline gear. Studies on hook design indicate that circle hooks are effective in reducing deep ingestion of hooks by loggerhead turtles (Bolten et al, 2002 unpublished report) and circle hook designs have the potential to reduce leatherback foul hooking (2001 Canadian report, unpublished). The combination of circle hooks and mackerel bait has the potential to reduce leatherback foul hooking and loggerhead interaction with longline gear and deep ingestion of hooks.

Below is a summary of the proposed 2002 NED experimental design which includes sample sizes required to evaluation proposed mitigation treatments and estimated sea turtle takes. The estimated sea turtle takes do not exceed the takes estimated in the original permit application and mitigation measures to be tested will in fact reduce the impact on sea turtles. The mitigation measures are highly likely to reduce interactions by at least 25% and the numbers of control hooks that will be used are 50% less than originally proposed in the application for permit. "Use of circle hooks significantly decreased the rate of throat hooking in loggerhead turtles. This result has important implications for reduced sea turtle mortality." (Bolten et al, 2002). The proposed experimental design using circle hooks will likely significantly reduce the number of loggerhead turtles which are throat hooked.

Based on the recommendations of an ad hoc pelagic longline gear working group the objectives for 2002 experiments in the NED are:

1. Evaluate the effect of reducing daylight soak time on turtle cpue
2. Evaluate the effect of 0º offset and 10 º offset 18/0 circle hook designs with squid bait on turtle cpue and rate of deep ingestion
3. Evaluate the effect of 25º-30º offset 9/0 J and 10º offset 18/0 circle hook with mackerel bait on turtle cpue and rate of deep ingestion

Sample size required to detect 25% reduction in loggerhead CPUE

SET A

Control A	25º-30º offset 9/0 J hook w/squid bait	54,054 hooks
Treatment B	0º offset 18/0 circle hook w/squid bait	54,054 hooks

SET B

Control A	25º-30º offset 9/0 J hook w/squid bait	54,054 hooks
Treatment C	10º offset 18/0 circle hook w/squid bait	54,054 hooks

SET C

Treatment D	25º-30ºoffset 9/0 J hook w/mackerel bait	54,054 hooks
Treatment E	10º offset 18/0 circle hook w/mackerel bait	54,054 hooks

Total 324,324 hooks

Sample size required to detect 50% reduction in loggerhead deep ingested hooks 57,771 hooks per treatment.

Sample size required to detect 50% reduction in leatherback turtle interactions 26,828 hooks per treatment.

Experimental Fishing Design Requirements

Alternate Sets A and B and C

SET A – Alternate control A and treatment B with 3 hooks between floats, first hook immediately adjacent to each float and equal distance between hooks two and three and next float.

SET B – Alternate control A and treatment C with 3 hooks between floats, first hook immediately adjacent to each float and equal distance between hooks two and three and next float.

SET C - Alternate treatment D and treatment E with 3 hooks between floats, first hook immediately adjacent to each float and equal distance between hooks two and three and next float

Each vessel must alternate the set configurations listed above. For every set the vessel will deploy the gear with 3 hooks between each float, one placed directly adjacent to each float and the other two placed between the floats equal distance from each other. The first set in the series (A) will alternate control J hooks baited with squid and 0º offset 18/0 circle hooks baited with squid (figure 2). The second set in the series (B) will alternate control J hooks baited with squid and 10º offset 18/0 circle hooks baited with squid (figure 2). The third set in the series will alternate control J hooks baited with mackerel and 10º offset circle hooks baited with mackerel (figure 2).

Daylight Soak Time

Vessels must attempt to have longline gear out of the water between 10AM and 1:00PM The objective is to have a spread of haul end times across the time slot of 10AM and 1:00PM. Hauls end times need to be as evenly spaced across this time slot as possible. Haul end times can fall outside of these time slots, if necessary, but every attempt should be made to spread haul end times uniformly across this time slot. (**set times <u>must</u> not be any earlier than one hour before sunset and preferably at sunset).**

This procedure will provide spread in the daylight soak times that will enable us to better define the relationship between daylight soak time and turtle CPUE and at the same time test the effect of reducing daylight soak time on turtle CPUE.

Gear standardization requirements: *

1. Hook spacing must be consistent within a trip.
2. Hook fished immediately adjacent to each float.
3. Drop line and leader lengths and size must be consistent within a trip.
4. Green light sticks must be used on every leader and must be 1 ½ to 2 fathoms from the hook for all trips
5. Leaded swivels must be used on every leader and must be 2 to 3 fathoms from the hook.
6. Mainline, drop line, and leader color and size must be consistent within a trip
7. Hook designs must be consistent for all vessels (NMFS will purchase all treatment hooks for the experiments to ensure consistency).
8. Squid bait used should be illex squid between 150 and 300 grams in weight.
9. Mackerel bait should be Boston mackerel between 200 and 500 grams in weight
10. Method of baiting must be consistent within a trip
11. Control hooks will be supplied by each vessel and must be one of the following hook types:

    Mustad 9/0 # 7698 RD
    LP-SW 9/0
    Eagle Claw 9/0 # 9016
    Mustad 9/0 # 76801

12. Treatment hooks will be supplied by NMFS:

    LP SS 0º offset 18/0 circle hook
    LP SS 10º offset 18/0 circle hook

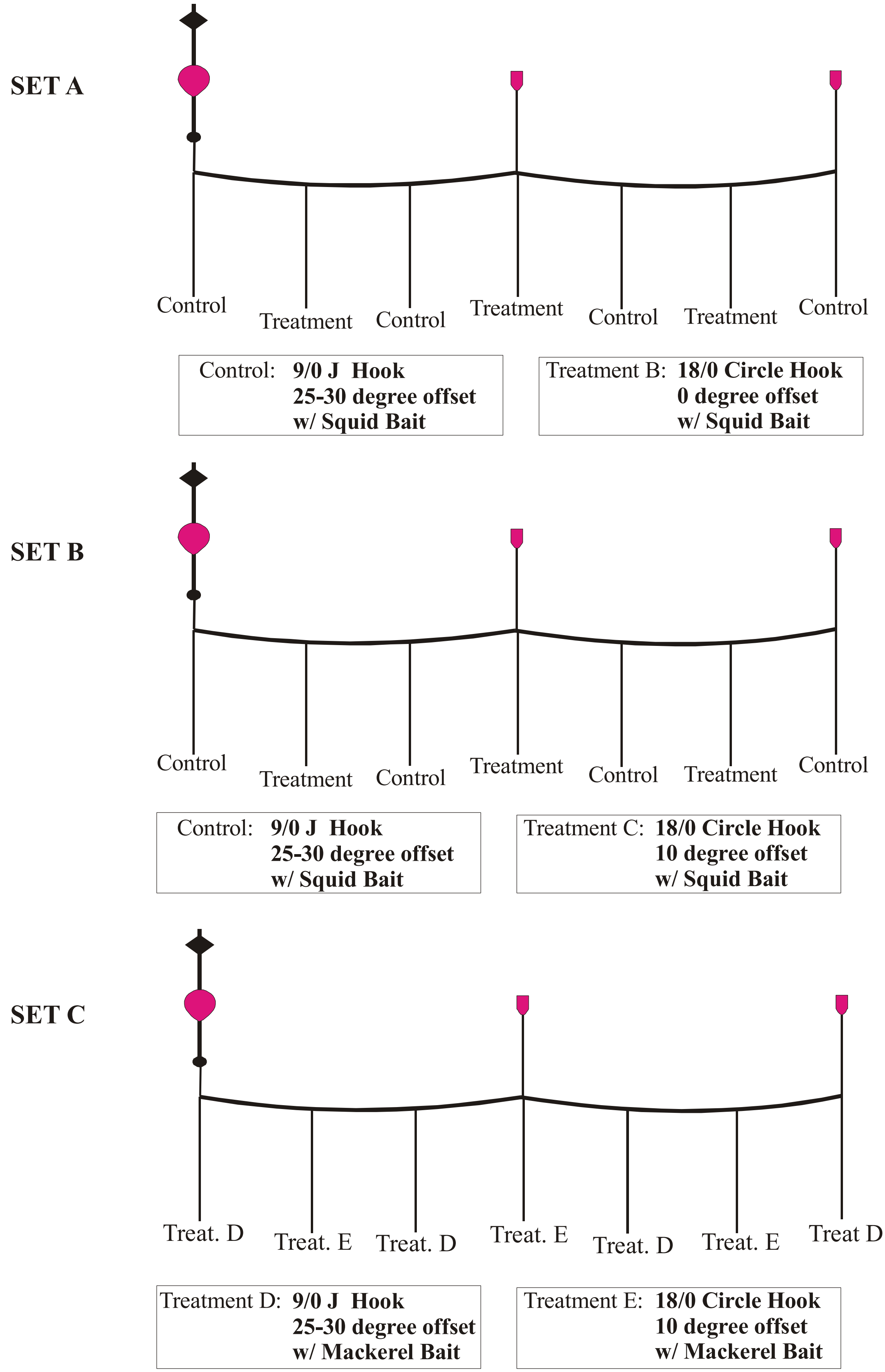
13. All leaders or snaps must be color coded in a manner that allows positive identification of hook type used.

* If for reasons beyond the control of the vessel operator, standardization of gear cannot be met i.e. supplies not available, the vessel operator or owner must notify NMFS and receive approval for waiver before departing on a trip.

Observers will collect a suite of data on forms generated by the SEFSC Pelagic Longline Observer Program including the Longline Gear Configuration Log, the Longline Haul Log, and the Individual Animal Log, and the Sea Turtle Life History Form (Appendix I). Observers will record the number of swordfish and turtles hooked on each hook and bait type, the time, location, and water temperature at which each section of gear is set and hauled, and the time, location, and water temperature at which each turtle is hauled. Participating captains, crews, and observers will follow NOAA guidelines and permit requirements for handling marine turtles hooked or entangled on longline gear. Specific training on handling marine turtles hooked or entangled will be provided by NMFS qualified personnel at observer and captain training sessions prior to initiation of experiments. Turtles hooked or entangled will be brought on board using dip nets if size permits and all gear removed following recommended procedures. For turtles that cannot be brought aboard, gear will be removed using line cutter and de-hooker prototypes supplied by NMFS to each vessel. Prototype line cutters and de-hookers will be evaluated by crews and observers and information on performance provided to NMFS. All live turtles brought aboard will be tagged with standard flipper tags and released. Turtles that appear stressed will be maintained onboard and given the opportunity to revive before release. Up to 20 loggerhead turtles may be outfitted with conventional satellite tags to study the behavior and movements of pelagic stage turtles. An additional number of turtles (up to 10) may be outfitted with archival pop-up satellite tags (PSAT) for the purpose of evaluating their effectiveness for the study of turtle life history, and to investigate the effectiveness of the technique for collecting information on post hooking survival.

The estimates of catch rates per hook of control and treatment groups will be computed from the sample data. Using these estimates, a one-tailed hypothesis test will be conducted to test if the true catch rate for the treatment group is lower than that of the control group. Since the sample proportions are estimated from a large number of hooks, a test based on asymptotic normality to compare the two binomial proportions will be used here at a pre-specified level of significance. A confidence interval on the difference in the true proportions will also be computed. The Fisher's exact test and the likelihood ratio test will be performed as well and examined. Statistical analysis will include descriptive statistics, confidence intervals and hypothesis testing procedures on a single and multiple rates and proportions, measures of correlations and associations, generalized linear modeling (logistic and Poisson regression, in particular) and other categorical analytical approaches as deemed appropriate.

Figure 2: Set Configurations



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